

General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.
- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

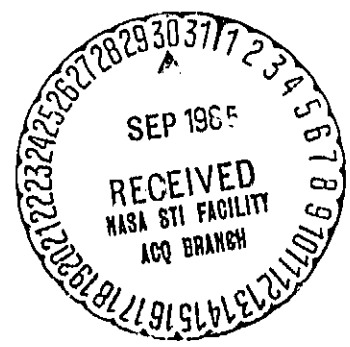
SPT

Display Copy
Don't Remove from Room

NASA CR-167865

COMPARATIVE ANALYSIS OF OPERATIONAL FORECASTS VS ACTUAL WEATHER CONDITIONS IN AIRLINE FLIGHT PLANNING

VOLUME IV



PRC SPEAS

DIVISION OF PRC PLANNING AND ECONOMICS, INCORPORATED

PREPARED FOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

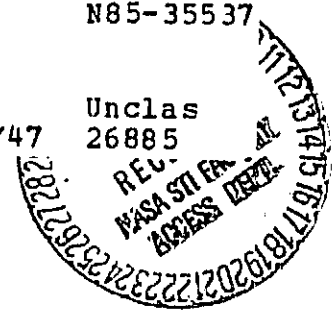
(NASA-CR-167865) COMPARATIVE ANALYSIS OF
OPERATIONAL FORECASTS VERSUS ACTUAL WEATHER
CONDITIONS IN AIRLINE FLIGHT PLANNING,
VOLUME 4 (PRC Planning and Economics, Inc.)
93 p HC A05/MF A01

N85-35537

CSCL 04B 33/47

Unclas
26885

NASA LEWIS RESEARCH CENTER
CONTRACT NAS 3-22748



1. Report No. NASA CR-167865		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Comparative Analysis of Operational Forecasts vs. Actual Weather Conditions in Airline Flight Planning - Volume IV				5. Report Date April 1982	
				6. Performing Organization Code	
7. Author(s) John F. Kaletz				8. Performing Organization Report No.	
9. Performing Organization Name and Address PRC Speas - Division of PRC Planning & Economics, Inc. 3003 New Hyde Park Road Lake Success, New York 11042				10. Work Unit No.	
				11. Contract or Grant No. NAS 3-22748	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546				13. Type of Report and Period Covered Contractor Report	
				14. Sponsoring Agency Code	
15. Supplementary Notes Project Manager, Robert Steinberg, Aircraft Propulsion Division, NASA Lewis Research Center, Cleveland, Ohio 44135					
16. Abstract <p>A study was conducted on the impact of more timely and accurate weather data on airline flight planning with the emphasis on fuel savings. This volume of the report discusses the results of Task IV of the four major tasks included in the study. Task IV used flight plan segment wind and temperature differences as indicators of dates and geographic areas for which significant forecast errors may have occurred. An in-depth analysis was then conducted for the days identified. The analysis showed that significant errors occurred in the operational forecast on 15 of the 33 arbitrarily selected days included in the study. Wind speeds in an area of maximum winds were underestimated by at least 20 to 25 kts. on 14 of these days. The analysis also showed that there is a tendency to repeat the same forecast errors from prog to prog. Also, some perceived "forecast errors" from the flight plan comparisons could not be verified by visual inspection of the corresponding National Meteorological Center forecast and analyses charts, and it is likely that they were the result of weather data interpolation techniques or some other data processing procedure in the airlines' flight planning systems.</p>					
17. Key Words (Suggested by Author(s)) Aircraft fuel savings Weather Flight planning North Atlantic track system				18. Distribution Statement	
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 91	
				22. Price*	

* For sale by the National Technical Information Service, Springfield, Virginia 22161

TABLE OF CONTENTS

	<u>Page Number</u>
1. INTRODUCTION.....	1
2. SUMMARY AND KEY FINDINGS.....	2
2.1 Forecast Errors.....	6
2.2 Other Errors.....	7
3. ANALYSIS METHODOLOGY.....	10
4. FINDINGS.....	15

1. INTRODUCTION

PRC Speas, assisted by David R. Bornemann Associates, Inc., has conducted analyses of flight plan data for the National Aeronautics and Space Administration-Lewis Research Center under Contract #NAS3-22748.

The objective of these analyses was to assess the potential improvement in fuel savings which may be possible from improved meteorological data. Flight plans calculated from prescribed input parameters and meteorological data sets were used as quantitative indicators of differences in fuel burn and other relevant parameters. Flight plan data were provided by two airlines which will be referred to as "BLUE Airlines" and "RED Airlines" throughout this report in order to maintain anonymity.

The work program under this contract was divided into four tasks. This volume of the final report presents the findings of Task IV. Task IV consisted of analysis of and commentary on significant forecast errors that occurred on those days in 1979 for which data were collected for Task I of this study.

Subsequent sections of this volume describe the methodology for the Task IV analysis and present the findings.

2. SUMMARY AND KEY FINDINGS

In the Task IV analysis, differences between flight plan winds and temperatures based on the National Weather Service forecast and on the verifying analysis from Task I were used as indicators of dates and geographic areas for which significant forecast errors may have occurred. The objective of Task IV was to review available forecasts and verifying analyses valid at the forecast time so as to explain forecast errors which occurred and to discuss their significance.

Days on which the forecast resulted in flight plan segments with wind direction differences greater than 30 degrees, speed differences greater than 20 kts., or temperature differences greater than 5°C, between the plan on the forecast and the plan on the verifying analysis, were designated for further analysis.

Key findings of this analysis were:

- BLUE Airlines data indicated that forecast errors that were judged to be significant and extensive existed on 13 of the 33 arbitrarily selected days included in the study. RED Airlines data indicated that significant errors existed on an additional 18 days, but all but two of these were excluded from further analysis because much of the RED data were found to be erroneous and unreliable.
- On 14 days of the 15 considered to have significant forecast errors, wind speeds in an area of maximum winds were underestimated by at least 20 to 25 kts., and on at least four days by more than 50 kts.

- There is a tendency to repeat the same forecast errors from prog to prog even though the intervening analysis showed clearly that errors had occurred.
- Five days of the 15 were found to have significant errors in the forecast of the location, movement, development or intensity of the major synoptic scale features.
- Some perceived "forecast errors" from the flight plan comparisons could not be verified by visual inspection of the corresponding National Meteorological Center forecast and analyses charts, and it is likely that they were the result of weather data interpolation techniques or some other data processing procedure in the airlines' flight planning systems. This was especially apparent in areas where there was a sharp gradient in the wind direction or wind speed.

A summary discussion of the analysis and other findings follows.

The comparisons of flight plan segments from Task I identified 2,349 segments for which the wind or temperature differences exceeded the limits (30 degrees, 20 kts. or 5°C). Many of these "error segments" were widely scattered or isolated geographically and of little significance. Others were clustered and consistent with other adjacent error segments. The isolated error segments were ignored, while those that appeared in patterns of synoptic scale or large areal extent were identified for further analysis.

For those dates and geographic regions so identified, other data provided by NASA were reviewed. These normally consisted of the National Meteorological Center (NMC) 250 mb. forecasts and analyses valid at 0000Z on the day under review and 0000Z on the following day. 250 mb. level analyses prepared by an airline were also used for some days.

The RED and BLUE Airlines data from Task I initially identified forecast errors on 31 of the 33 arbitrarily selected days included in the study. In Section 4 of this volume a summary is presented for each day which gives the number of RED and BLUE Airlines flights, the number of error segments, the areas in which forecast errors occurred and a discussion of the extent and significance of the errors.

Further review of the data revealed an inconsistency in the RED and BLUE Airlines data from Task I.

A substantially higher number of error segments were found for RED Airlines even though it operated fewer flights. For the BLUE Airline there were 853 flights and 908 error segments for an average of 1.06 per flight. For the RED Airline 262 flights encountered 858 error segments for an average of 3.2 per flight. If the Mid East segments are excluded the BLUE Airlines error segments are reduced to 528 for 651 flights, or an average of 0.8 per flight.

Since both airlines used the same weather data, it is obvious that there are differences in their interpolation algorithms since only one detected apparent "forecast errors" when both operated flights through the same area.

Further investigation showed that the RED Airlines winds were often completely incompatible with either the forecast or the verifying

analysis. (For example, see the data for November 26 in Section 4.) Wind direction errors of up to 180 degrees occurred on days, and in geographic areas, on which the BLUE Airlines data showed few or zero errors.

It was decided that some error in the data interpolation or flight planning algorithm in the RED system was causing an apparently erroneous identification of error segments.

When the BLUE data alone were considered, 10 of the 33 days were found to have forecast errors of significant magnitude and areal extent. For three additional days, the BLUE Airlines error segments indicated relatively minor forecast errors but, upon visual inspection of the forecast and analysis charts, it was determined that significant errors existed but were not detected by the BLUE Airlines flights which were not routed near the forecast error area.

Even though most of the forecast errors indicated by the RED flight plans were discarded because they were not consistent with the other data, on two days the errors indicated by RED Airlines were confirmed by visual inspection of the charts and were judged to be significant.

Thus, between the RED and BLUE data, 15 of the 33 arbitrarily chosen forecast rerun days were found to have significant forecast errors.

2.1 FORECAST ERRORS

Data for the 15 days identified two types of repetitive and significant errors. These were underestimated wind speeds, and repetition of forecast errors.

Underestimated Wind Speeds

A persistent error found throughout the analysis was the underestimation of wind speeds. In 14 of the forecast error situations the forecast maximum winds were at least 20 to 25 kts. and sometimes more than 50 kts. lighter than actual. Wind speeds further away from the core were proportionately in error out to the 70 kt. or 50 kt. level where the errors become insignificant.

Wind speed forecast errors were also found on five additional days but these were judged to be less significant errors because of their lesser magnitude and extent.

Repetition of Forecast Errors

In the analysis it was noted that apparent forecast errors were not corrected on subsequent forecasts. Review of the forecasts issued 12 or 24 hours later showed that errors such as the wind speed errors noted above were carried from prog to prog even though the intervening analysis showed many actual observations of data that were in disagreement with the forecast. A forecast, for example, that showed a maximum wind isotach of 90 kts. would be followed by another with a 90 kt. maximum

isotach value even though winds of 125 to 135 kts. were observed at the valid time of the prog. Sometimes, the same situation would have occurred 24 hours earlier and 24 hours later, as well, with the forecasts giving no indication of the existence of the stronger winds.

This repetition of the forecast errors was confirmed on five days of the 33 reviewed. There were indications that forecast errors were repeated on many of the other days but it was not possible to confirm this since data were only retained for the days involved in the study, and thus, data for the adjacent forecast periods were not always available.

Location of Synoptic Features

Even though there were frequent errors in wind speed forecasts, as noted above, the forecasts of the location, movement, development and intensity of synoptic scale features were usually quite accurate. On five days the forecasts were judged to have significant errors of this nature. Typically, these consisted of such errors as underestimating the extent of deepening of a trough which resulted in an extensive area of wind direction errors. On three additional days, less significant errors of this type were noted.

2.2 OTHER ERRORS

Analysis of the error segments and visual inspection of the corresponding forecast and analysis charts found several other errors which may have been perceived as forecast errors but are likely the result of some

procedure or feature of the airline flight planning systems. These are discussed below.

Time Interpolation and Choice of Prog

It was apparent from the analysis that time interpolation between weather progs, or the choice of prog on which the flight plan is based, caused some of the wind differences between the forecast and analysis, especially in rapidly changing situations. On several days, (for example, see the discussions for August 24 or September 7 and Figure 4-6 in Section 4) review of the 0000Z forecast and analysis, and review of the forecast and analysis valid 24 hours later showed that the forecasts were highly accurate, but flight plans based on an intervening forecast, such as the 1800Z, resulted in error segments. It is possible that in these few cases there were no forecast errors at all but rather that the flight planning algorithm or the analysis methodology somehow resulted in forecast winds being compared to actual winds valid at a different time.

Average Winds in Areas of Sharp Gradient

The methodology by which these airlines develop the average winds for a flight plan segment may have resulted in some "forecast errors". Both airlines use some scheme to determine an average wind for a flight plan segment from adjacent Marsden Square data. Since some flight plan segments can traverse more than one Marsden Square, in areas of sharp gradient flight plan winds may be developed by averaging very light winds with very strong winds, depending on the algorithm being used. This

averaging process appears to have resulted in some apparent forecast errors on the flight plans, which do not appear when one visually compares the forecast and analysis charts. An example of this problem is presented in the discussion for November 9 and in Figure 4-19.

This problem applies equally to situations with a pronounced wind direction gradient. Many forecast error segments were found near the centers of highs, lows, ridges or troughs where the wind direction changes rapidly with distance.

Mid-East Errors

Significant "forecast errors" were noted on 11 days in the Mid East area by BLUE Airlines. Even on other days there were usually some error segments but they were judged to be relatively insignificant and not worth further analysis. Often these "errors" were on the same routes day after day - routes through Yugoslavia, Turkey, Syria, Iraq, and Iran. The charts that were available did not extend far enough east to be of help in explaining the forecast errors in this area. However, it is believed that the persistent, almost daily, occurrence of forecast errors in this area is significant on its own even if the significance of the individual daily errors cannot be determined. Since it is difficult to explain how a forecast error should occur in the same location so often, it was assumed that this was the result of some anomaly in the BLUE Airlines system.

3. ANALYSIS METHODOLOGY

The objective of Task IV was to identify and comment on forecast errors from the Task I analysis. During the computer processing of the data in Task I, flight plan segments with a wind speed difference of 20 knots or more, wind angle difference of 10 degrees or more, or a temperature difference of 5°C or more between the plan on an operational forecast and the plan on the verifying analysis were identified for further analysis in Task IV.

Approximately 118,000 flight plan segments were considered in this analysis and some 19,000 were identified as exceeding one or more of the three forecast error criteria. The objective of this task was not to explain the reason for the forecast error for each of these 19,000 segments but rather to explain forecast errors over larger areas that were of synoptic scale significance. The individual flight plan segments were only to be used to identify the areas that required further manual analysis.

It was decided, therefore, with the approval of the NASA project manager that the 19,000 forecast error segments, representing 16 percent of all segments, probably indicated that the forecast error criteria were too stringent and that the objective of Task IV would still be served if the wind angle difference criterion were eased. The segment comparison was

then rerun using 30 degrees difference in wind angle as the indicator of a forecast error. The wind speed and temperature criteria were kept at 20 knots and 5°C, respectively.

Using these criteria, 2,349 segments were identified as exceeding one or more of the limits. These data were then reviewed manually, and subjectively, to determine the days and geographic areas for which significant forecast errors occurred which should be analyzed further.

In general, isolated segments with forecast errors were ignored unless some adjacent segments supported the conclusion that a significant synoptic scale error existed in the area. Similarly, areas with large wind direction errors but with very low speeds (under 10 knots) were generally assumed to be insignificant unless supported by errors in adjacent segments.

Except for these two types of occurrences, however, most other segment errors were assumed to be significant enough to warrant further analysis.

Since data from both BLUE Airline and RED Airline flight plans were included in the analysis some flight plan segments may indicate forecast errors that are really just the result of differences in the weather data interpolation algorithm between the two systems. There were some days on which one system identified numerous forecast "errors" while the other

identified very few. These cases were always retained for further analysis to determine whether or not there was a real forecast error.

Figure 3-1 lists the days and areas of the world that were identified for further review. The number of flights by each airline and the number of segments for which the forecast vs. verifying analysis difference exceeded the criteria are also included along with the nominal forecast valid time and the predominant direction of traffic flow on the North Atlantic. (The number of segments listed is the number of unduplicated segments with forecast errors. If two or more flights traversed the same segment and reported the same wind or temperature error the segment was only counted once. Similarly, those days which only included a few isolated segment errors are not listed. Thus, the total number of segments in Figure 3-1 does not add to 2,349.)

For each day listed in Figure 3-1, PRC Speas reviewed additional data provided by NASA. These data normally included the National Weather Service 24-hour 250 mb. prog, the 24-hour tropopause-vertical wind shear prog, and the 250 mb. analysis valid at the time of the 250 mb. prog above. For some days, especially during October and November, each of these progs and analyses was not always available and a forecast valid 12 hours later or earlier was reviewed to explain what might have happened during the period for which the data were missing. 250 mb. operational analyses prepared by an airline were also used to substitute for missing data. In certain cases, where preliminary analysis indicated that it was

Figure 3-1

TASK IV RESULTS
DATES AND AREAS WITH FORECAST ERRORS

Date	No. of Flights		Segments With Errors		Type Flow	Prog Valid Time	Areas With Forecast Errors
	BLUE	RED	BLUE	RED			
1/15	12	17	0	14	E/B	06	NAT, E. Canada
1/19	0	20	0	8	E/B	06	NAT, No. Sea
8/6	19	12	15	58	E/B	06	NAT, E. Europe, E. Canada
8/7	27	8	45	29	W/B	18	NAT, Europe
8/10	36	5	93	44	E/B	06	NAT, Mid East
8/13	25	0	36	0	W/B	18	NAT, Europe, Mid East
8/14	32	9	60	42	E/B	06	NAT, Europe, Mid East
8/17	38	0	87	0	W/B	18	NAT, Europe, Mid East
8/20	24	7	29	13	E/B	06	Europe
8/24	36	10	25	17	W/B	18	NAT, Mid East
9/7	34	10	42	102	W/B	18	NAT, Mid East, W. United States
9/10	0	12	0	33	E/B	06	NAT, Canada
9/14	21	2	19	7	W/B	18	NAT, E. United States
9/17	30	8	23	19	E/B	06	NAT, W. Europe
9/21	34	11	66	41	W/B	18	NAT, Europe, Mid East
9/24	0	6	0	16	E/B	06	E. United States, E. Canada
9/28	44	13	64	53	W/B	18	NAT, Europe
10/5	0	8	0	31	W/B	18	NAT, E. United States
10/8	18	0	33	0	E/B	06	NAT, Mid East
10/12	27	7	14	10	W/B	18	NAT, E. Canada
10/15	21	9	34	45	E/B	06	NAT, Europe
10/19	29	6	25	18	W/B	18	NAT, Mid East
10/26	20	5	18	15	W/B	18	Europe, E. Canada, Mid East
11/2	31	3	42	20	W/B	18	NAT, Europe, Mid East
11/5	28	2	2	24	E/B	06	NAT
11/9	42	13	21	10	W/B	18	Europe, United States
11/12	33	6	8	40	E/B	06	NAT
11/16	34	10	21	56	W/B	18	NAT, Europe
11/19	34	12	8	11	E/B	06	NAT, Europe
11/23	44	14	28	35	W/B	18	Europe, Canada
11/26	26	7	5	37	E/B	06	NAT, E. Canada, W. Europe

Source: PRC Speas Analysis

appropriate, certain additional data such as the North Atlantic Organized Tracks were considered.

In the next section of this report, each case is discussed separately. The forecast error segments are identified, the synoptic situation is summarized, and the significance of the errors is discussed.

4. FINDINGS

Findings of the Task IV analysis are presented on the following pages. The cases which were listed in Figure 3-1 are presented in date order. Each day that was reviewed is discussed here even though it was decided subsequently that for some days data anomalies attributed to the RED Airlines weather data processing algorithm erroneously identified forecast errors. In each case the areas with forecast errors are defined and the extent and magnitude of the errors are summarized. The significance of the errors is discussed and any other comments deemed appropriate are presented. Figures are used to depict graphically some situations where it was believed they would contribute to better understanding of the discussion. The discussion and figures presented here are meant to provide the reader with a very brief description of the forecast errors. A thorough treatment would require reference to more data than would be practical to reproduce here.

For each day reviewed, the number of flights that provided data is given along with the number of flight plan segments that exceeded one or more of the forecast error criteria. These are referred to as "error segments" in the discussion and are those segments for which the wind or temperature differences between the flight plan on the forecast and the flight plan on the analysis exceeded 30 degrees, 20 knots, or 5°C.

In the remainder of this section of the report winds will be presented in the format DDD/FFF where DDD is the direction in degrees and FFF (or FF if appropriate) is the speed in knots. The range of wind values over some geographic area will be presented as DDD to DDD/FFF to FFF. Differences between winds on the plan based on the forecast and the plan based on the analysis will be presented in the same format. Temperatures will be presented in the format TT (or TT to TT for a range of values) where TT is degrees Celsius.

DATE: January 15, 1979

Eastbound Flow

DATA SOURCES: BLUE Airlines - 12 flights - zero error segments
RED Airlines - 17 flights - 14 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Maine, New Brunswick, Nova Scotia	200 to 220/50 to 70	20 deg. and 20 to 25 kts.
Vicinity of 51N45W	340/90	10 deg. and 20 kts.
Vicinity of 53N between 30W and 15W	200 to 220/100 to 115	20 to 30 kts.

BLUE Airlines Data

No Errors

DISCUSSION: The only data from this date that were available for review were the 24-hour 250 mb. forecasts valid at 00Z on January 15th and 16th. The corresponding analyses were not available and without them it is difficult to comment on the apparent forecast errors listed above or even to confirm that errors did in fact exist and were not merely the result of anomalies in the time interpolation algorithm in the RED Airlines flight planning system.

In any case, based upon the small number of error segments and on the BLUE Airlines findings, it is likely that the errors were not significant.

DATE: January 19, 1979

Eastbound Flow

DATA SOURCES: RED Airlines - 20 flights - 8 error segments

FORECAST ERRORS:

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Area bounded by 53N, 55N, 40W and 20W	270 to 290/85 to 145	20 to 35 kts.
North Sea	290/40	30 deg.

DISCUSSION: For this date only the 250 mb. forecasts valid at 00Z on January 19th and 20th were available for review. As was the case with the January 15th data, it was not possible to comment on the significance or extent of the relatively few and minor forecast errors listed above without access to the corresponding actual analyses for that day.

DATE: August 6, 1979

Eastbound Flow

DATA SOURCES: BLUE Airlines - 19 flights - 15 error segments
RED Airlines - 12 flights - 58 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Vicinity of New Brunswick, Nova Scotia, and Newfoundland	230 to 260/60 to 110	0 to 80 deg. and up to 70 kts.
British Isles	240/35 to 50	40 to 50 deg.

BLUE Airlines Data

Eastern Canada	(consistent with above findings)	
Along a line between Cairo and Athens	250/65	20 to 35 kts.

DISCUSSION: Figure 4-1 depicts the orientation of streamlines and location of the 100 kt. and 50 kt. isotachs from the 250 mb. analysis of 00Z August 7th. Maximum winds within the 100 kt. isotach were 115 kts.

The corresponding 250 mb. forecast chart valid at 00Z was not available for review, but based upon review of the forecasts valid at 00Z on August 6 and 12Z on August 7, and the analysis at 00Z on August 6, one can comment on the likely extent and significance of the forecast error.

These data indicate that the forecast of the shape, and movement of the trough in eastern North America was quite accurate. However, the wind speeds on the east side of the trough were underestimated. Both of the forecast charts showed maximum winds within a 70 kt. isotach east of the trough even though the actual analyses showed winds up to 115 kts. at 00Z on August 6 as well as 24-hours later.

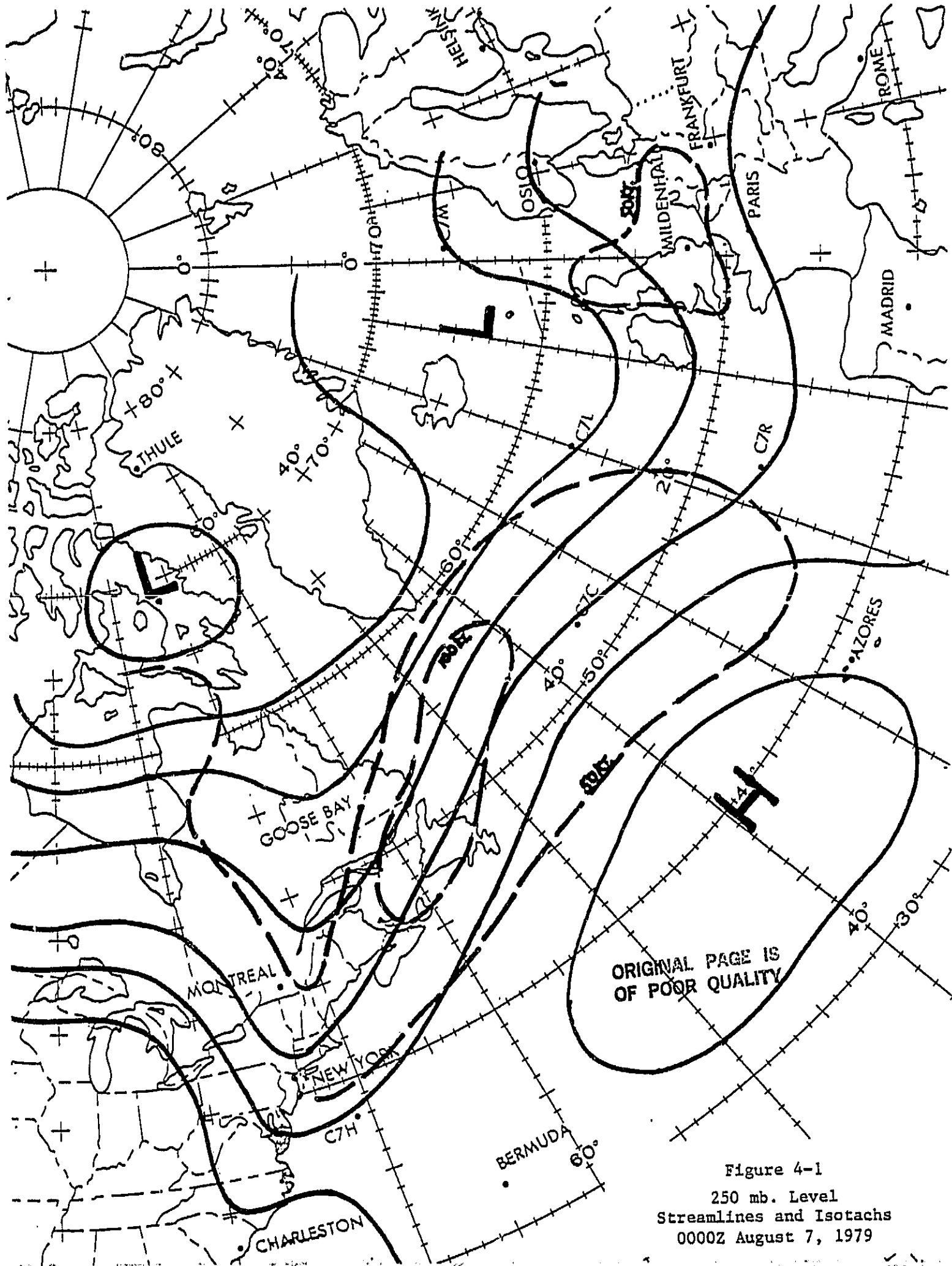


Figure 4-1
 250 mb. Level
 Streamlines and Isotachs
 0000Z August 7, 1979

DATE: August 6, 1979 (Continued)

The flight plan error segment data confirm these findings. The segments with large direction errors were right in the center of the trough where the winds were light. The segments on the east side of the trough generally had zero to ten degree errors in direction but up to 70 kts. in speed.

The forecast errors in the British Isles area are wind direction errors only and appear to be the result of unforecast deepening of the trough west of Ireland along with a slower than expected easterly movement of the trough.

Available data do not extend far enough east to explain the forecast error between Cairo and Athens.

DATE: August 7, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 27 flights - 45 error segments
RED Airlines - 8 flights - 29 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Vicinity of British Isles	230 to 270/20 to 50	30 to 50 deg. and 8°C
Area Bounded by 20W, 40W, 40N and 50N	Variable/30 to 40	40 to 60 deg. and 7 to 8°C
Area Bounded by 20W, 40W, 60N and 65N	270/60 to 70	25 to 30 kts. and 6 or 7°C

BLUE Airlines Data

Mid-Atlantic	(consistent with above findings 20W to 40W)	
Through Yugoslavia, Greece, Turkey, Iraq and Iran	240 to 270/20 to 70	20 to 40 deg. and 25 kts.

DISCUSSION: Figure 4-1 may be used for reference regarding the general synoptic situation since it is based upon the August 7, 00Z analysis. At 00Z on August 8 the situation was quite similar but with the trough moving east to the vicinity of Gander and filling slightly, the ridge in the Atlantic moving to 35W and building, and the trough that was off the Irish Coast moving east to the center of England with some deepening. The area of maximum winds moved from the east side of the trough to the top of the ridge and increased in speed and areal extent. The August 8, 00Z analysis shows maximum winds of 135 kts. extending from 50N through 58N.

The forecast of the location of the major features was quite accurate. However, the forecast did not show the building of the ridge, overestimated the extent of the filling of the

DATE: August 7, 1979 (Continued)

Gander trough, and projected filling of the trough over England when it actually deepened. On the forecast the maximum wind isotach was increased to 90 kts. at the top of the ridge, but as mentioned above, the actual maximum winds in this area increased from 115 kts. to 135 kts. over this 24-hour period and the width of the band of 120 kt. winds increased by some 300 nm.

All of the segment forecast errors in the British Isles were largely direction errors only and are explained by the unforecast deepening of the trough which changed the orientation of the streamlines.

The wind direction errors in the area between 40N and 50N at 20W to 40W were the result of a mislocation of the closed high at 30W. The errors were not significant operationally in either of these areas.

There were not sufficient observational data on the NMC analysis to explain the segment forecast errors in the Mid East nor the temperature errors in the Mid North Atlantic.

DATE: August 10, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 36 flights - 93 error segments
RED Airlines - 5 flights - 44 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Eastern Canada, entire North Atlantic between 45N and 65N, and Western Europe	230 to 280/70 to 100	30 to 160 deg., 20 to 25 kts., 12°C

BLUE Airlines Data

Eastern North Atlantic and Ireland	(consistent with above findings)	
Vicinity of Yugoslavia, Turkey, Iraq and Iran	240 to 270/40 to 70	30 to 40 deg. and 15 to 25 kts.

DISCUSSION: Figure 4-2 presents streamlines and isotachs from the 250 mb. analysis valid at 00Z on August 11th for reference during the following discussion.

From inspection of the 250 mb. analyses and forecasts valid at 00Z on August 10 and August 11 it can be concluded that the RED Airline data used in Task I for this day were somewhat erroneous. The winds on the flight plans on the forecasts and the flight plans on the analysis are substantially different from the corresponding winds on the NMC charts issued at those times.

In any case, even if the RED Airlines data are ignored, several BLUE Airlines error segments and the NMC forecast and analysis charts confirmed that wind forecast errors of 10 to 25 degrees and up to 24 kts. existed in the vicinity of the ridge at 20W.

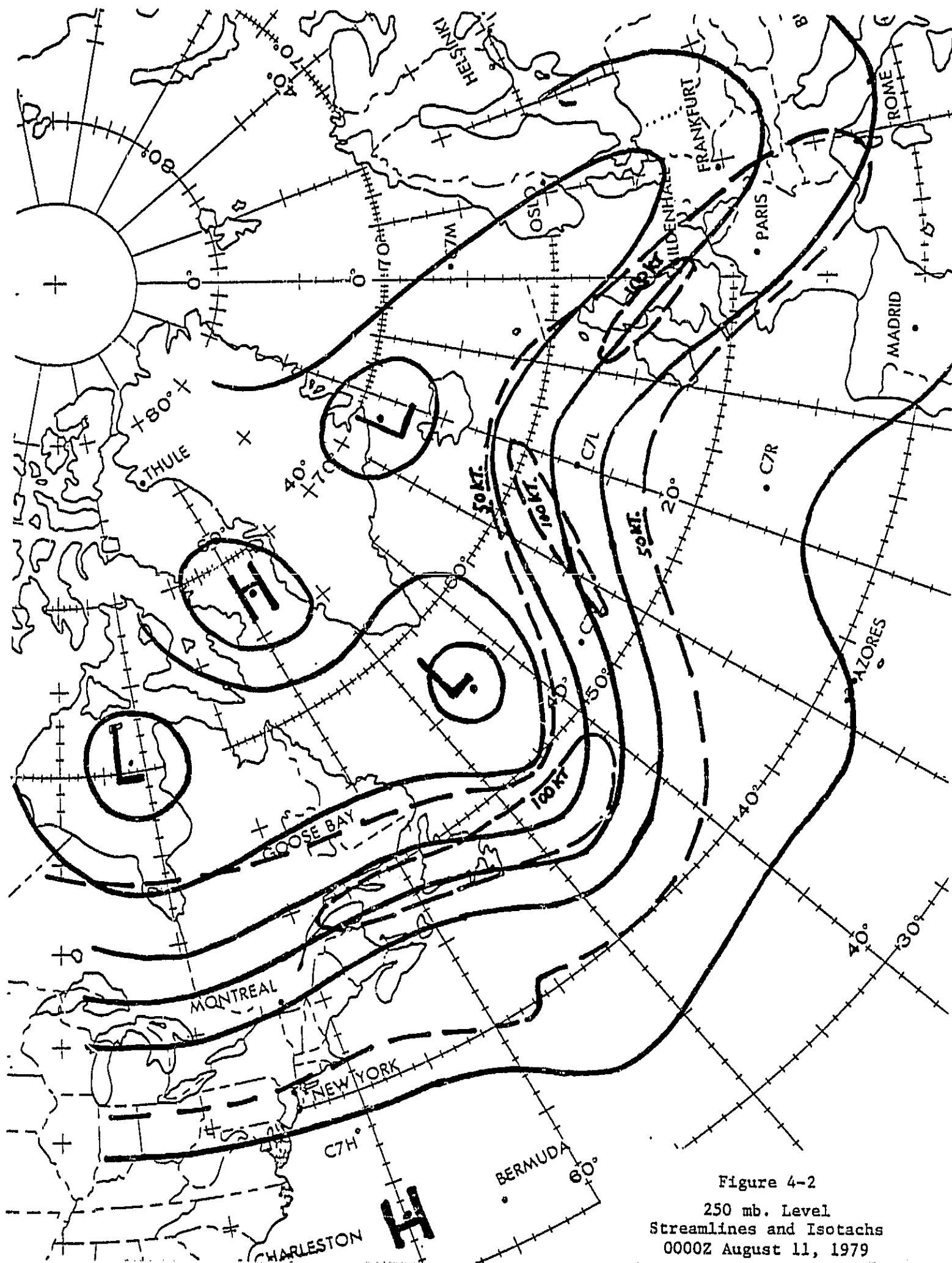


Figure 4-2
 250 mb. Level
 Streamlines and Isotachs
 0000Z August 11, 1979

DATE: August 10, 1979 (Continued)

With respect to location, intensity and movement of the major features, the forecast valid at 00Z on the 11th was quite close to the actual analysis of Figure 4-2 except for the orientation of the ridge at 20W. In the forecast the ridge was oriented approximately along a line from 50N20W to 65N35W rather than in the north-south alignment shown in the actual analysis. This accounted for the slight wind direction errors in the eastern North Atlantic.

The wind speeds were underestimated throughout the entire period. The 00Z analysis of August 10th showed a band of maximum winds 70 to 95 kts. about 300 nm. wide across the top of the ridge and winds of up to 125 kts. on the west side of the ridge. The 24-hour forecast for 00Z on the 11th, however, showed only 50 kt. isotachs extending across the top of the ridge and a maximum wind area of more than 70 kts. in the west side of the ridge. The analysis valid at 00Z on the 11th showed winds of up to 115 kts. extending to the top of the ridge indicating the likelihood of errors up to 50 to 65 kts. It is surprising that the BLUE Airlines data only indicated errors of up to 24 kts.

Regarding the areas of forecast error in Eastern Europe and the Mid East it appears that the wind direction errors in the Yugoslavia area were caused by the forecast of the deep trough in that area being some 200 miles east of its actual position. Further into the Middle East, the height contours are much more flat and at the edge of the available charts and it is not possible to explain the forecast errors with the available data.

DATE: August 13, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 25 flights - 36 error segments

FORECAST ERRORS:

BLUE Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Vicinity of 48N45W	270/50	10 deg. and 25 kts.
Vicinity of 53N50W	220/70	40 deg.
Vicinity of 56N35W	300/100	30 to 35 kts.
Eastern France	330 to 030/20 to 30	30 to 40 deg. and 20 to 30 kts.
Vicinity Turkey-Iran	230/90	20 to 25 kts.

DISCUSSION: Isotachs and streamlines in Figure 4-3 depict the actual winds on the North Atlantic at 00Z August 14th. The errors noted above for the North Atlantic area are based upon six flight segments from four eastbound flights and two westbound flights. Thus, based on the BLUE Airlines data alone the forecast errors do not appear to be significant. However, review of the 250 mb. forecasts valid at 00Z on August 13th and 12Z on August 14th (the 00Z forecast for August 14th was not available) indicated that the location and orientation of the major systems were forecast quite accurately, but the maximum wind speeds were underestimated throughout the entire period. The forecast valid at 00Z on the 13th showed a narrow band of 110 kt. winds on the west side of the mid-Atlantic trough (which was not yet as deep). By 12Z of August 14th the maximum wind isotach in the west side of the trough was 90 kts. and covered a band some 350 miles wide with a second area of 90 kt. winds on the east side of the trough. The actual analyses showed maximum winds of up to 150 kts. in a narrow band on the west side through the bottom of the trough at 00Z on the 13th with 100 kt. winds on both sides of the trough similar to the 00Z August 14th situation depicted in Figure 4-3.

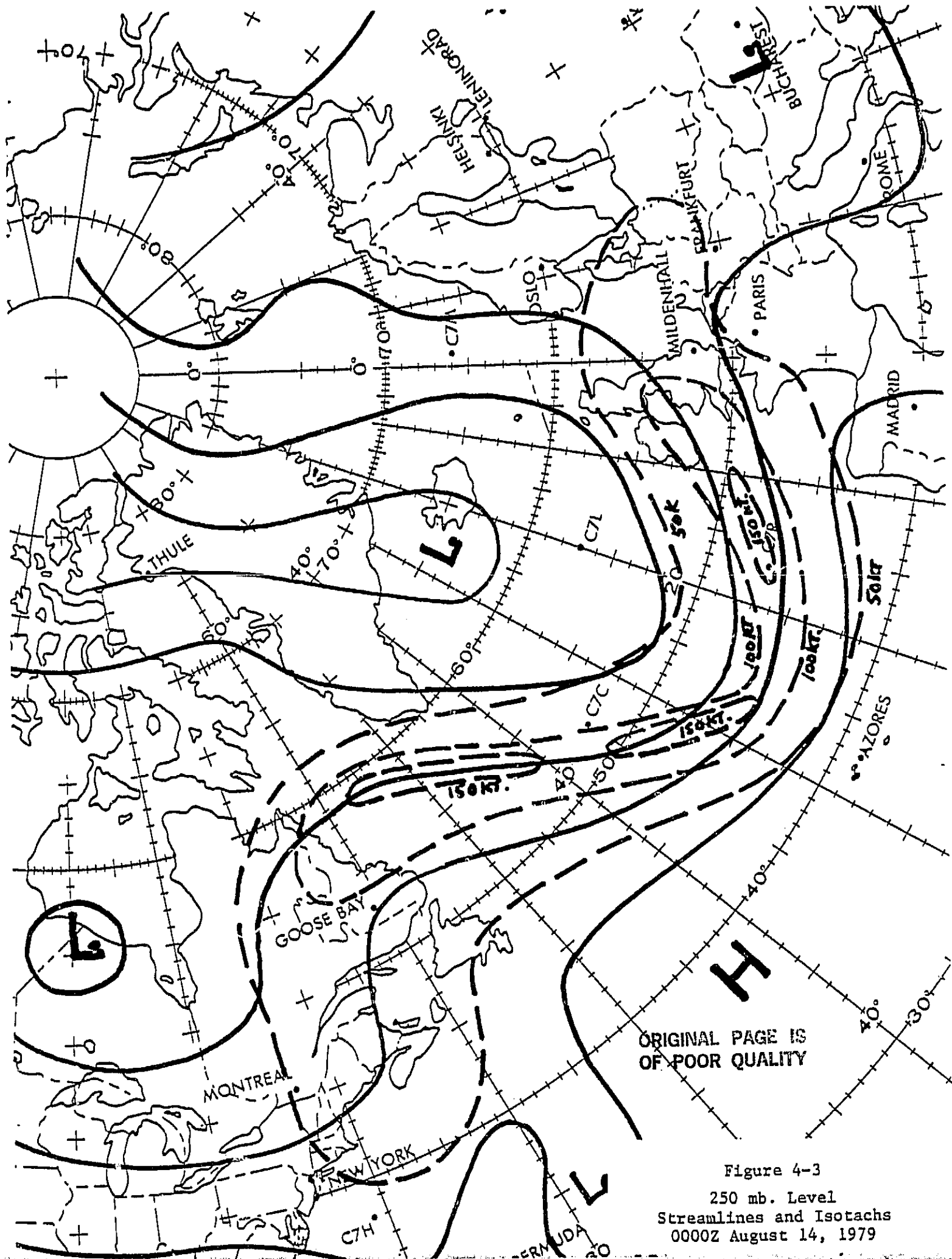


Figure 4-3
250 mb. Level
Streamlines and Isotachs
0000Z August 14, 1979

DATE: August 13, 1979 (Continued)

The relatively small errors in wind direction and speed in eastern France were the result of the unexpected deepening of the low centered in Yugoslavia. However, these were of little operational significance.

DATE: August 14, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 32 flights - 60 error segments
RED Airlines - 9 flights - 42 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
British Isles, North Sea Scandinavia	200 to 240/40 to 110	20 to 50 deg. and 20 to 30 kts.
57N between 20W and 40W	260 to 290/65 to 95	20 to 40 kts. 6°C
Vicinity of 65N Between 10W and 60W	180 to 270/10 to 40	20 to 150 deg. and 20 to 25 kts.

BLUE Airlines Data

Vicinity 54N25W	290/100	20 to 40 kts.
Vicinity 54N50W	260/75 to 100	20 to 30 kts.
Vicinity Turkey, Iraq, Iran	240 to 360/20 to 100	20 to 60 deg. and 20 to 40 kts.

DISCUSSION: Figure 4-3 valid at 00Z on August 14th may be used for reference during the following discussion. By 00Z on the 15th, the situation was similar except that the low south of Hudson Bay moved eastward to southeastern Quebec and filled slightly, the trough in the Mid-Atlantic moved eastward about 12 degrees of latitude and deepened somewhat, the ridge between them was approximately along the 40W meridian and building, and the low in Yugoslavia deepened with a ridge building between it and the Atlantic trough.

The winds were generally lighter throughout the entire area with maximum winds of 125 kts. to 130 kts. in the west side of the Atlantic trough and in the east side of the Quebec trough. The width of the band of 100 kt. winds is reduced to some 100 to 150 nm. throughout the Atlantic area.

DATE: August 14, 1979 (Continued)

Inspection of the 250 mb. forecast valid at 00Z on August 15th suggests that the NMC model suffered a substantial forecast "bust" on that day. It missed:

- The easterly movement and filling of the Quebec low, leaving it centered in James Bay;
- The building of the ridge at 40W;
- The movement and deepening of the Atlantic trough, leaving it centered at 15W about 3 to 5 degrees west of its actual position;
- The development of the ridge in western Europe.

This resulted in a forecast with a more zonal orientation of the streamlines across the ocean and forecast winds from 250 to 290 degrees. The sharper features resulted in actual winds ranging from about 200 degrees to 320 degrees.

Because of its areal extent, it is likely that this forecast error had a substantial operational impact on airlines. For example, the RED Airlines data from Task I show that every westbound flight had forecast errors on every segment from the origin to landfall on the North American side of the ocean.

DATE: August 17, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 38 flights - 87 error segments

FORECAST ERRORS:

BLUE Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Vicinity of Gander to 50N40W	230/75 to 95	20 to 25 kts.
60N to 65N and 10W to 60W	270/20 to 40	25 to 45 deg. and 7 to 8°C
Vicinity of England and France	300 to 320/70 to 90	25 to 35 kts.
Eastern Europe Through Germany, Italy, Yugoslavia and Greece	240 to 290/20 to 80	20 to 30 kts.

DISCUSSION: Figure 4-4 depicts the streamline and isotach fields that existed at 00Z on August 18th, at the 250 mb. level.

Review of the 250 mb. forecast valid at 00Z on August 18th and the analyses for 00Z on the 17th and the 18th verifies that the forecast was actually quite good except for some relatively small wind speed errors. Most of the error segments were clustered around Newfoundland or around the west coast of France and southwestern England. The wind directions in the forecast were accurate but the speeds were too low on both sides of the ridge in the Atlantic.

The forecast showed a maximum isotach value of 70 kts. on the west side of the ridge where the actual winds were up to 110 kts. The actual winds above 100 kts. were in a very narrow band, however, while the forecast area of 70 kts. was up to 600 nm. wide. On the east side of the ridge, the forecast showed maximum winds of 90 kts. and they were more to the west and northwest of Ireland. Figure 4-4 shows that the core of maximum winds was actually up to 110 kts. and was further into the trough south and southeast of Ireland.

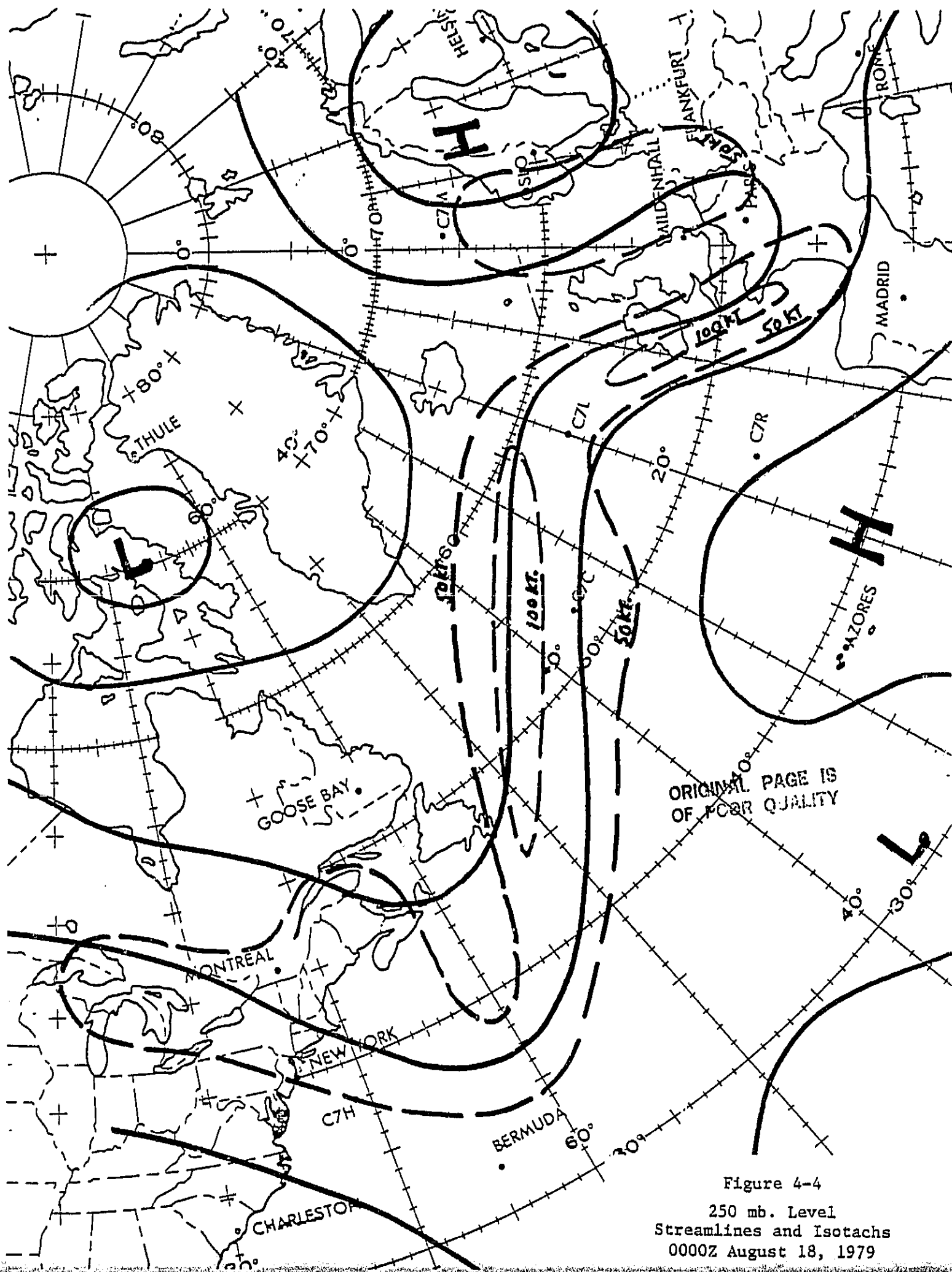


Figure 4-4
 250 mb. Level
 Streamlines and Isotachs
 0000Z August 18, 1979

DATE: August 17, 1979 (Continued)

The other areas with error segments in eastern Europe and along 65N were both near the centers of lows where the flow is ill-defined, the wind speeds are light, and the errors are of little operational significance.

DATE: August 20, 1979

Eastbound Flow

DATA SOURCES: BLUE Airlines - 24 flights - 29 error segments
RED Airlines - 7 flights - 13 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
France and England	240 to 260/30 to 80	25 to 35 kts.

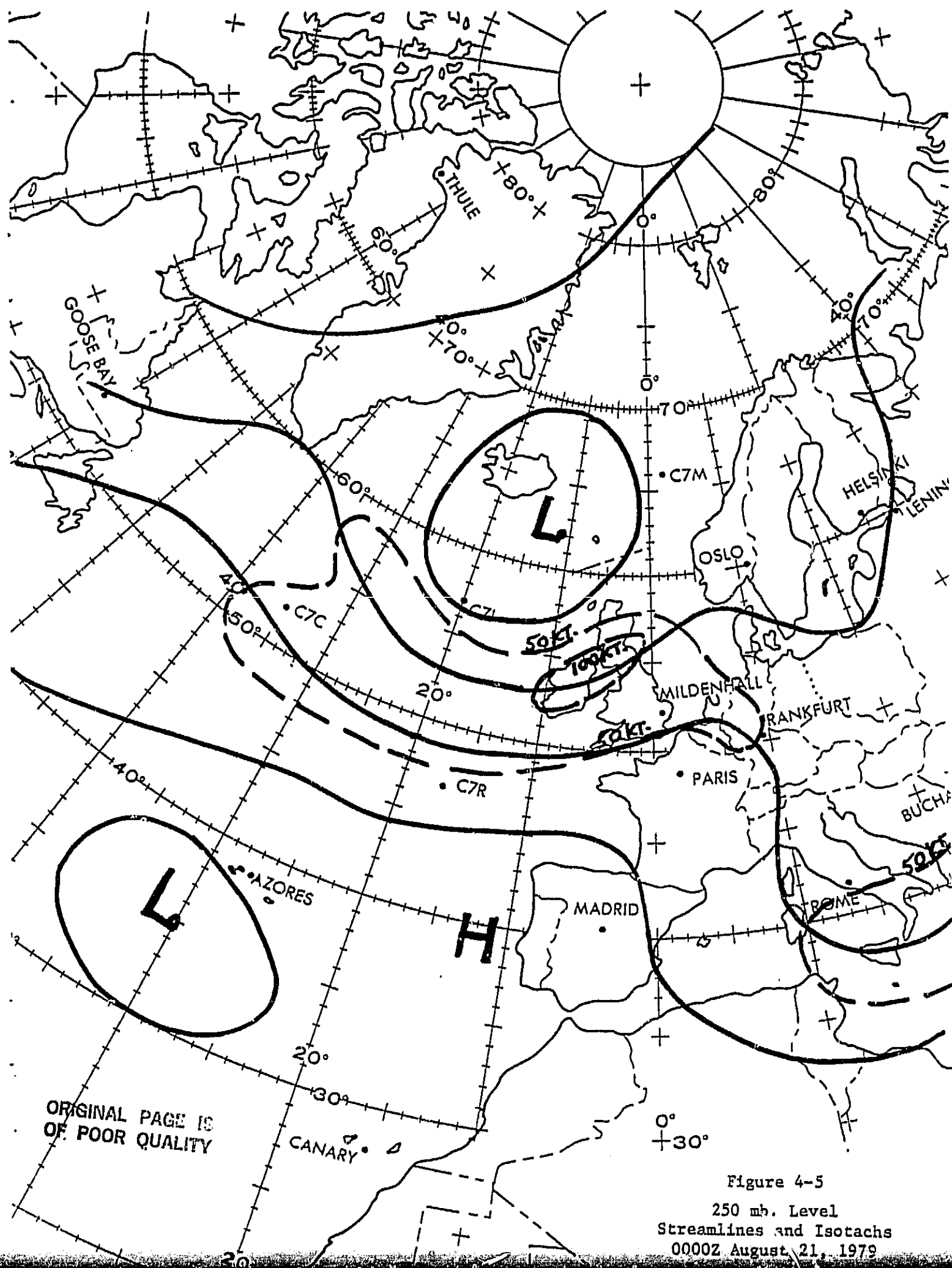
BLUE Airlines Data

Southern and Eastern Europe Through Austria, Italy, Greece, Yugoslavia, and Turkey	350 to 020/15 to 35	30 to 50 deg.
---	---------------------	---------------

DISCUSSION: Figure 4-5 depicts the streamline and isotach fields over Europe and the eastern North Atlantic, where all the error segments occurred, for 00Z on August 21 at the 250 mb. level.

Review of the 250 mb. forecast and analysis valid at 00Z on August 21 makes it clear that the forecast was actually quite accurate. The few error segments detected only by RED Airlines data in western Europe were apparently the result of slightly underestimating the extent of the deepening of the low southeast of Iceland. The forecast 250 mb. height contours showed a height of 10,210 meters at the center of the low and the actual was approximately 10,150 meters. The forecast included a maximum wind isotach of 70 kts. over Ireland and the adjacent ocean area while the actual winds were up to 105 kts. over Ireland and Scotland as Figure 4-5 shows.

Review of the forecast and analysis in the eastern European area did not support the error segment findings above. The forecast was nearly perfect in this area and the wind direction errors on the BLUE Airlines flight plans must have been the result of some other factor related to that airline's flight planning system.



ORIGINAL PAGE IS
OF POOR QUALITY

Figure 4-5
250 mb. Level
Streamlines and Isotachs
0000Z August 21, 1979

DATE: August 24, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 36 flights - 25 error segments
RED Airlines - 10 flights - 17 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
England and France	240 to 260/30 to 85	20 to 35 kts.

BLUE Airlines Data

Between 10W, 50W, 40N and 45N	230 to 270/30 to 85	15 to 40 deg., 10 to 25 kts., 6°C
Over Iran	260 to 280/23 to 36	30 to 50 deg., 10 to 15 kts.

DISCUSSION: Figure 4-6 shows the approximate streamline and isotach fields from the 250 mb. analysis from 00Z on, August 25th. Wind barbs indicate the location of several isolated observations of 100 kts. or greater. These were not extensive enough to include a 100 kt. isotach on a figure of this scale.

Although it is not apparent from the information given above, it turns out that all but one of the error segments in the North Atlantic area were for westbound flights. As such, it is likely that they operated on the 12Z prog. or 18Z prog. of August 24. Only the forecasts and analyses for 00Z on August 24 and August 25 were available for review in explaining these forecast errors.

The erroneous winds from the flight plans in Task I do not match either the forecasts or analyses reviewed and, in fact, the 00Z forecast is quite close to Figure 4-6, even to the point of being within 10 kts. of the maximum winds in the ridge in the middle of the Atlantic.

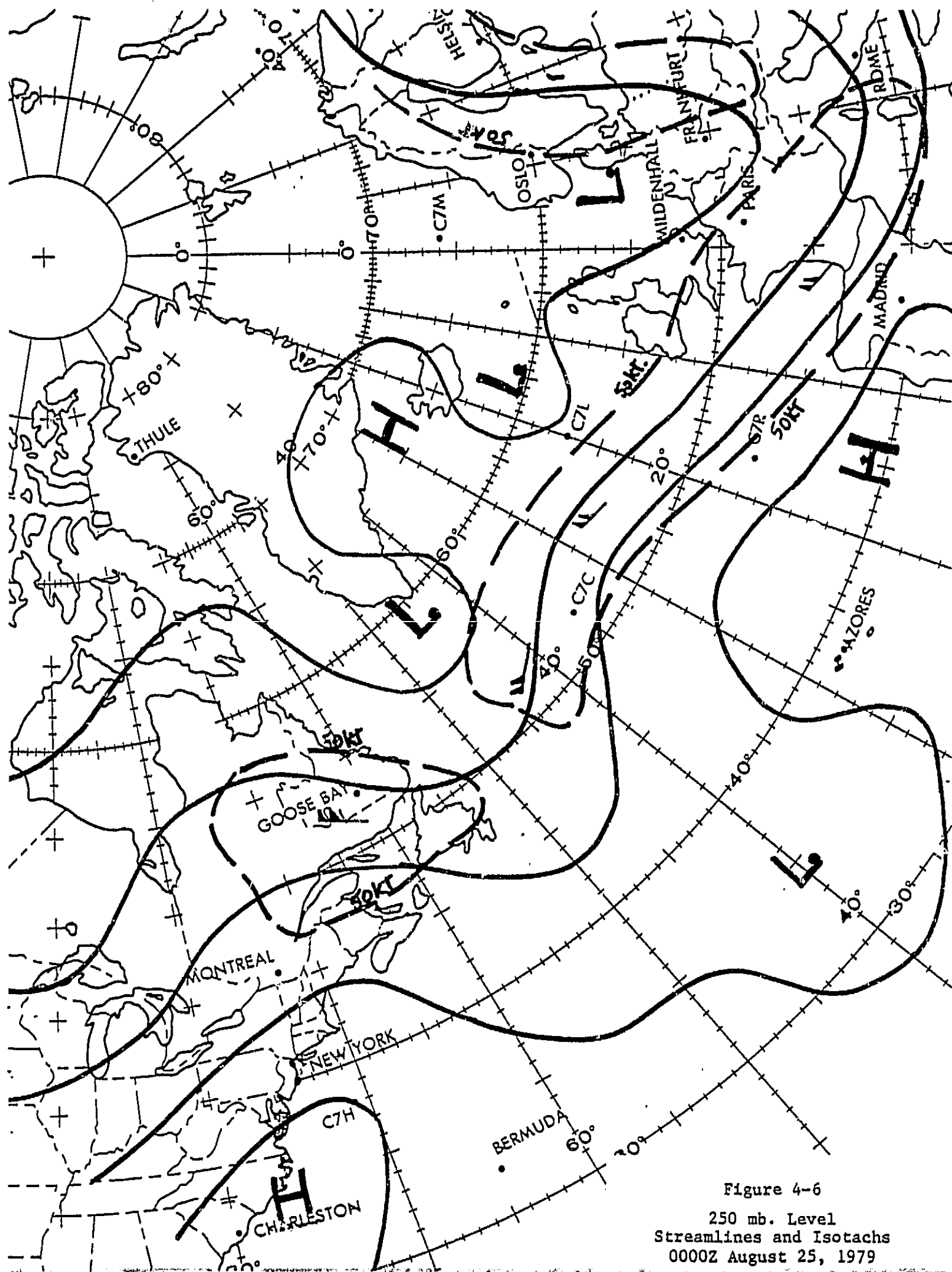


Figure 4-6
250 mb. Level
Streamlines and Isotachs
0000Z August 25, 1979

DATE: August 24, 1979 (Continued)

From review of the 00Z forecast from August 24th it appears that the NMC model underestimated the deepening and eastward movement of the two troughs (one approximately at 50W and the other over the North Sea). This apparently carried over to the 12Z and 18Z forecasts, resulting in the error segments noted above, but was corrected by the forecast valid at 00Z of August 25th which has the intensity and location of these troughs depicted quite accurately.

In any event, the errors were relatively minor and were not likely to be of any operational significance.

DATE: September 7, 1981

Westbound Flow

DATA SOURCES: BLUE Airlines - 34 flights - 42 error segments
RED Airlines - 10 flights - 102 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
British Isles	230 to 260/30 to 60	10 to 80 deg., 10 to 45 kts., and 6 or 7°C
Area Bounded by 60N, 67N, 10W and 50W	260 to 300/40 to 90	20 to 160 deg., 30 to 65 kts., and 8 to 10°C
Area Bounded by 43N, 50N, 10W and 50W	Variable/40 to 75	50 to 150 deg., 15 to 35 kts., and 6°C
Between New York, Gander, and 43N55W	230 to 260/60 to 90	30 to 50 deg., 20 to 50 kts.
Along a Line From Montreal to 60N60W	270/30 to 65	50 to 90 deg., 15 to 25 kts., 6 to 9°C
Along a Line From Poste de la Baleine (GW) to Sault Ste. Marie to Chicago	270 to 300/20 to 70	30 to 60 deg., 10 to 20 kts., 3 to 9°C
Along a Line From Thunder Bay to Salt Lake City to Los Angeles	290/20 to 50	40 deg. and 40 kts.

BLUE Airlines Data

Vicinity of 58N15W	290/40	40 deg. and 10 kts.
Vicinity of 64N25W	290/60	28 kts.
Vicinity of Turkey and Iran	260 to 360/15 to 30	30 to 50 deg. and 10 to 25 kts.

DATE: September 7, 1981 (Continued)

DISCUSSION: Review of the 250 mb. forecast and analysis valid at 00Z on September 8th indicates that the extensive area of forecast error indicated by the RED Airlines data did not in fact exist. For the entire North Atlantic region and for eastern North America, the forecast and actual were nearly identical. The presence of only several isolated error segments in the BLUE Airlines data further supports this conclusion.

By reference to the 00Z analysis for September 7th, it was noted that the changes during this 24 hour period were rapid and pronounced. Since all of the RED Airlines flights were westbound it is likely that they were planned and operated on a forecast valid for the middle of this period such as the 12Z prog. of September 7th. The rapidly changing situation may have caused the RED Airlines' time interpolation scheme to produce apparent forecast errors at 12Z which do not appear on the subsequent 00Z analysis.

The forecast error indicated by the RED Airlines data on the Polar route between Thunder Bay, Salt Lake City and Los Angeles was valid. A ridge just east of the Rocky Mountains was not forecast to build as much as it did resulting in the wind direction and speed errors of approximately 40 degrees and 40 kts. Along most of this route segment this error had the effect of changing expected winds from quartering headwinds to headwinds and, as such, could have resulted in time penalties of several minutes to these flights.

As in the previous discussions, no comments will be offered regarding the BLUE Airlines forecast errors in the Mid East area. The geographic extent of the available data is not sufficient to ascertain the reason for the errors in this region.

DATE: September 10, 1979

Eastbound Flow

DATA SOURCES: RED Airlines - 12 flights - 33 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Along a Line From 70N40W to 66N20W to 61N10W to Prestwick	230 to 280/10 to 110	0 to 80 deg., 0 to 20 kts., and 7 to 11°C
Area Between 30W, 55W, 48N and 60N	(-40 to -50°C)	7 to 13°C
Vicinity Montreal	300/100	25 deg.

DISCUSSION: Figure 4-7 depicts the approximate streamline and isotach fields in the North Atlantic area at the 250 mb. level at 00Z on September 11th. Several temperatures are shown in boxes.

The wind forecast valid at that time was quite accurate, even to the point of depicting the maximum wind speeds within 10 kts. in the area south of Iceland.

The wind forecast errors encountered by the flight proceeding northwest from Prestwick appear to have resulted from two sources. The direction errors occurred in the segments toward the center of the low where the flow is ill defined. The principal speed errors were in the segments closer to the British Isles and were the result of the maximum winds indicated by the 100 kt. isotach moving slightly further east than expected.

The isolated wind direction error in the vicinity of Montreal cannot be confirmed by reference to the forecast or the analysis. The wind on the 250 mb. forecast over Montreal is 270/85 and on the analysis it is 270/80. It must be concluded that this apparent "error" was caused somehow in the RED Airlines flight planning system's data handling algorithm.

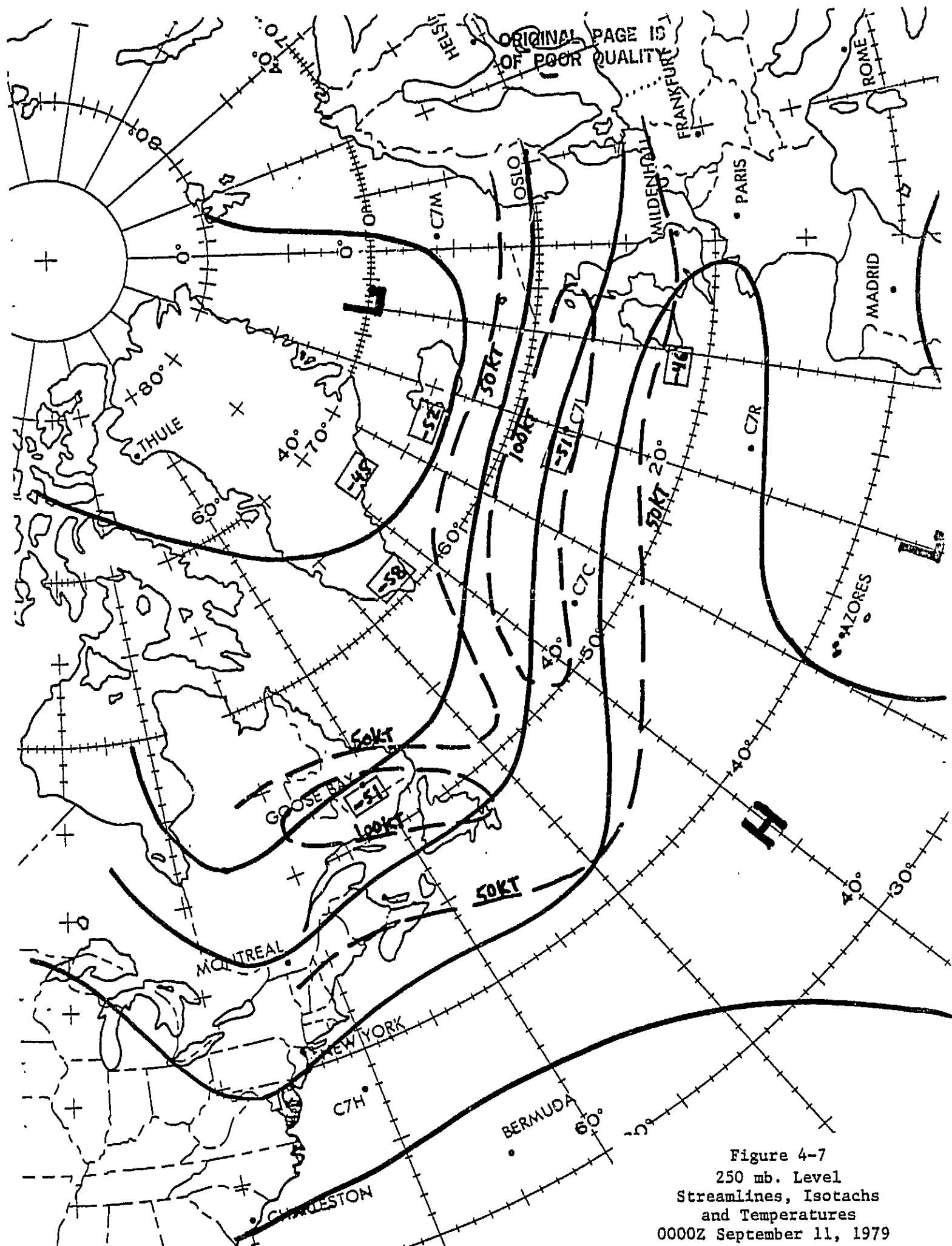


Figure 4-7
250 mb. Level
Streamlines, Isotachs
and Temperatures
0000Z September 11, 1979

DATE: September 10, 1979 (Continued)

The principal errors indicated above are temperature errors, especially in the area between 30W and 55W. However, no temperature observations were available in this area on the 250 mb. analysis and it is difficult to discuss or explain the apparent forecast error without more data. For those areas where temperature observations were available as indicated by the boxes in Figure 4-7 the temperatures were within 5°C of the forecast.

DATE: September 14, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 21 flights - 19 error segments
RED Airlines - 2 flights - 7 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Between 55N, 60N, 20W and 40W	200 to 220/60 to 100	10 to 35 deg., 25 to 35 kts.
Between Cartwright and 55N50W	290/110	10 deg. and 20 to 30 kts.

BLUE Airlines Data

Same areas and errors as above plus:

Vicinity Western Pennsylvania	235/99	41 kts. and 8°C
----------------------------------	--------	-----------------

DISCUSSION: Figure 4-8 depicts the isotachs and streamlines for the 250 mb. level at 00Z on September 15th.

The 24-hour forecast valid at that time depicted the location and intensity of the trough at 40W quite accurately. However, the wind speeds on either side of the trough in the area immediately adjacent to the center of the trough were underestimated resulting in the error segments noted above. These wind speed errors were much smaller than the typical errors that were found on many of the dates discussed in the preceding pages and were not likely to be of operational significance to airlines. In fact, further east of the trough, through the top of the ridge and down to the British Isles, most of the wind speeds indicated were within 10 kts. of forecast.

The error segments found in the vicinity of western Pennsylvania could not be confirmed by reference to the forecast and analysis charts. Wind speeds in this area were about 80 kts. on the forecast and 90 kts. on the analysis.

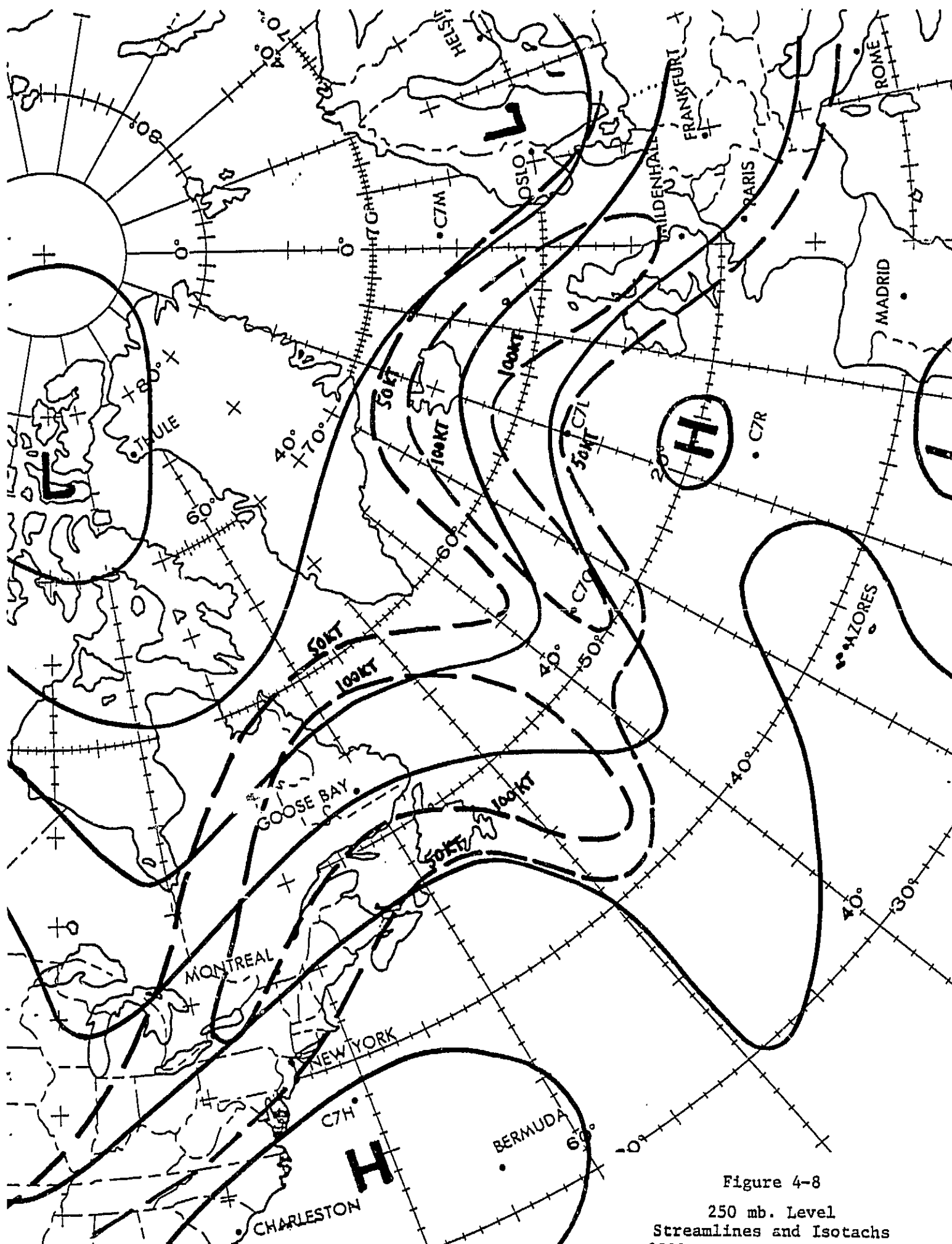


Figure 4-8
250 mb. Level
Streamlines and Isotachs

DATE: September 14, 1979 (Continued)

The previous OCZ forecast (for September 14th) called for winds of 30 to 40 kts. in this area and it may be that the BLUE Airlines error segments were the result of time interpolation or the choice of forecast period on which the flight plan was made in this rapidly changing situation.

DATE: September 17, 1979

Eastbound Flow

DATA SOURCES: BLUE Airlines - 30 flights - 23 error segments
RED Airlines - 8 flights - 19 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
30W to 40W, 52N to 57N	270/85 to 100	20 to 25 kts., 5 to 9°C
Vicinity of 45W53N	-	6 to 11°C
Vicinity of Gander	270/50	21 kts.
Vicinity of Poste de la Baleine	270/50 to 60	20 to 30 kts., 6°C

BLUE Airlines Data

57N15W	270/110	29 kts.
Eastern France, Northwestern Italy	330 to 030/10 to 25	40 to 70 deg.
Along a Line From 69N80W to 70N70W to 71N50W to 70N30W	290 to 320/18 to 20	30 to 100 deg. and 15 kts.

DISCUSSION: The approximate isotach and streamline fields from the 250 mb. level for 00Z on September 18th are shown in Figure 4-9. The few temperature observations that were available for the area of interest here are also shown in boxes in the figure.

Review of the 250 mb. analysis and forecast valid at 00Z on September 18th indicates that the forecast of the locations and intensities of the major synoptic features was quite accurate in the middle North Atlantic area. However, as was the case for many of the previous days reviewed, wind speeds were generally underestimated. This is confirmed by the dominance of speed errors rather than direction errors in the error segments listed above.

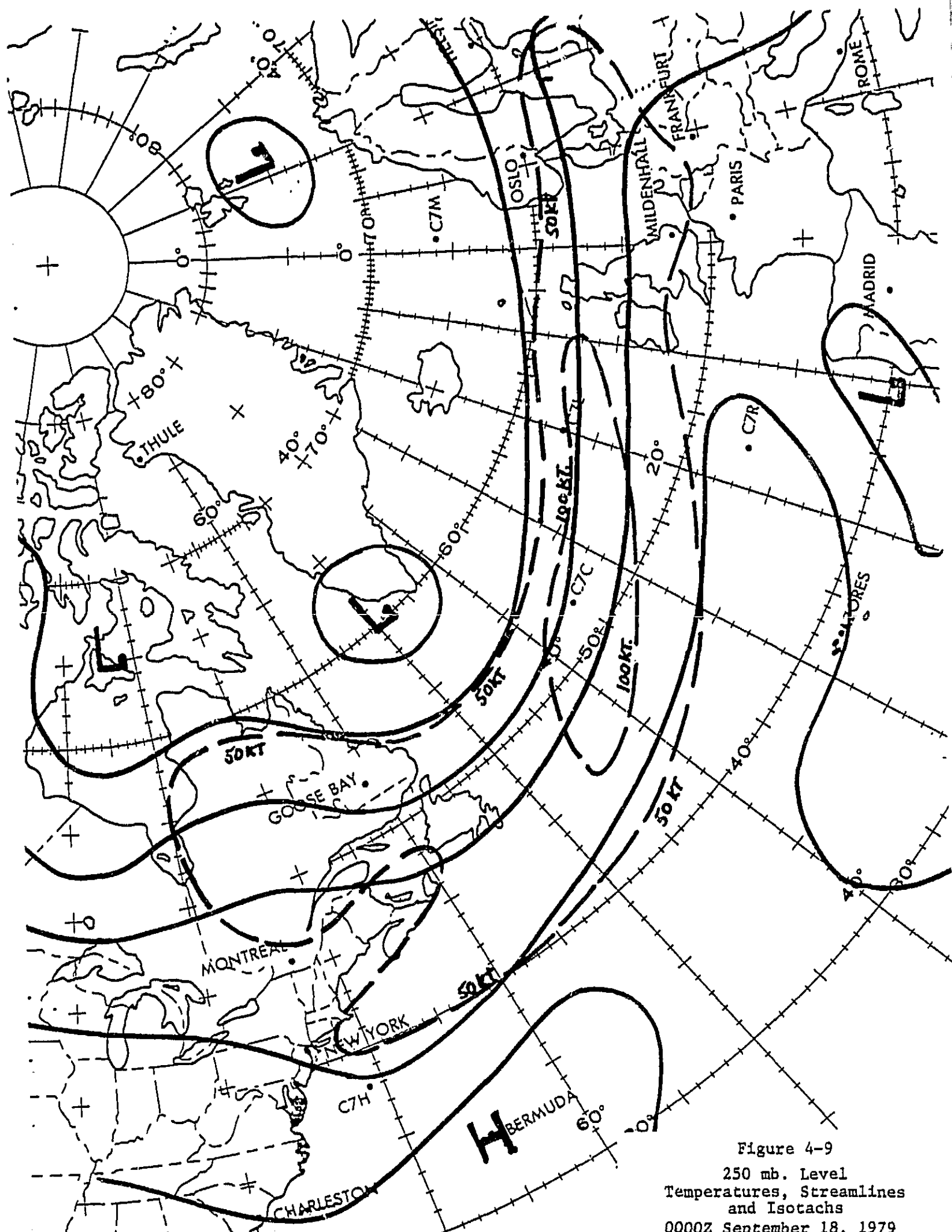


Figure 4-9
250 mb. Level
Temperatures, Streamlines
and Isotachs
0000Z September 18, 1979

DATE: September 17, 1979 (Continued)

The forecast chart showed a 90 kt. isotach in nearly the same location as the 100 kt. isotach in Figure 4-9. Actual wind speeds in this area were up to 145 kts.

Review of the forecast and analysis from 24 hours earlier (00Z on September 17th) revealed that maximum winds in this area were also underestimated. The forecast did show a 110 kt. isotach but the actuals were as high as 140 kts. Therefore, during the 24-hour period the forecasts reduced the maximum isotach from 110 kts. to 90 kts. even though the analysis showed maximums of 140 kts. increasing in speed to 145 kts. and in areal extent.

Sufficient observational data were not available to determine the cause of the temperature errors in the area between 30W and 50W. However, it was noted that the forecast indicated a temperature of -42 at 50N35W where the observed temperature was -43. A RED Airlines error segment in this vicinity noted a temperature difference of 8°C between forecast and actual.

The isolated wind speed errors in the vicinity of Gander and Poste-de-la-Baleine appear to be related to the unexpected development of the small trough over Hudson Bay and the adjacent ridge in eastern Canada. The forecast showed straight zonal flow throughout this area with winds of 70 kts. or more.

The wind direction errors in eastern France resulted from the greater than forecast deepening of the low over Portugal and another one in southwestern USSR, off the end of Figure 4-9. This caused a more northerly rather than northwesterly orientation of the streamlines over western Europe.

Finally, the wind direction errors along the route from 69N80W to 70N30W were judged to be of little significance since they were in the center of the low where variable winds and direction forecast errors are almost to be expected.

DATE: September 21, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 34 flights - 66 error segments
RED Airlines - 11 flights - 41 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Vicinity Maine and New Brunswick	270/115	21 kts.
Between 55N, 65N, 40W and 20W	240/90 to 125	20 to 45 kts., 8°C
England and Western France	350 to 360/110 to 135	30 to 50 kts.
Eastern France de la Baleine	180/50 to 70	20 to 30 kts., 6°C
Between 10W, 40W, 45N and 52N	Variable/10 to 30	30 to 160 deg., and 0 to 15 kts.

BLUE Airlines Data

Mid-Atlantic segments consistent with those above.

Vicinity of Germany and Austria	010/60	30 to 50 deg. and 35 kts.
Yugoslavia, Greece	160 to 200/10 to 30	30 to 50 deg. and 0 to 35 kts.
Vicinity of Turkey, Iraq and Iran	230 to 330/16 to 28	30 to 60 deg. and 5 to 15 kts.

DISCUSSION: Figure 4-10 is a sketch of the streamline and isotach fields that existed at the 250 mb. level on September 22, 1979 at 0000Z. The situation in the North Atlantic area, where most of the error segments were found, was dominated by the strong ridge along 20W and the deep trough over western

DATE: September 21, 1979 (Continued)

Europe. Reference to the previous 00Z analysis showed that this ridge and trough had developed rapidly and, although the locations were accurately forecast, the extent of the development was underestimated on the 250 mb. chart valid at 00Z on September 22.

The principal problem with this forecast, however, was the underestimated wind speeds throughout the ridge and trough, and in eastern North America as well. On the forecast, maximum winds in the vicinity of Maine and New Brunswick were enclosed by a 90 kt. isotach when they were actually 100 to 120 kts. in this area. On the west side of the ridge, maximum winds on the forecast were enclosed by a 90 kt. isotach of approximately the same size and in the same location as the 100 kt. isotach in Figure 4-10. Actual winds in this area were up to 140 kts. On the east side of the ridge, over the British Isles and through western France, the forecast showed a maximum wind isotach of 70 kts. where the actual winds were over 100 kts. with several observations of up to 150 kts. reported.

In each of these areas the previous analysis showed extensive areas of winds greater than 100 kts. with many observations of winds up to 150 kts. suggesting that even a simple persistence or continuity forecast would have called for higher and thus more accurate wind speeds.

On the east side of the trough through eastern France, Germany, Austria, Yugoslavia and Greece error segments were more the result of wind direction rather than speed errors. An unforecast low was developing over Turkey (beyond the area covered in Figure 4-10) which caused the secondary trough to develop extending to the southeast over Corsica. This caused a more southerly direction for the winds east of the main trough rather than the generally southwest direction that had been forecast.

DATE: September 24, 1979

Eastbound Flow

DATA SOURCES: RED Airlines - 6 flights - 16 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Along the Route From Chicago to Ottawa to Montreal	240 to 250/83 to 99	22 to 23 kts.
Maine, New Brunswick and Nova Scotia	250 to 270/112 to 118	28 to 31 kts.

DISCUSSION: The forecast errors identified above were restricted to a small area in the eastern United States and Canada. Figure 4-11 describes the situation that existed in this area at 00Z on September 25th. It appears that the deepening trough in the midwest influenced the winds in the area of forecast error. This forecast, and the one issued 24 hours earlier, showed a tendency toward decreasing wind speeds in the trough as it developed, and moved the stronger winds further east.

Actually the analysis showed that wind speeds did diminish substantially right along the centerline of the trough but remained strong to the east of the trough over the areas where the forecast errors occurred.

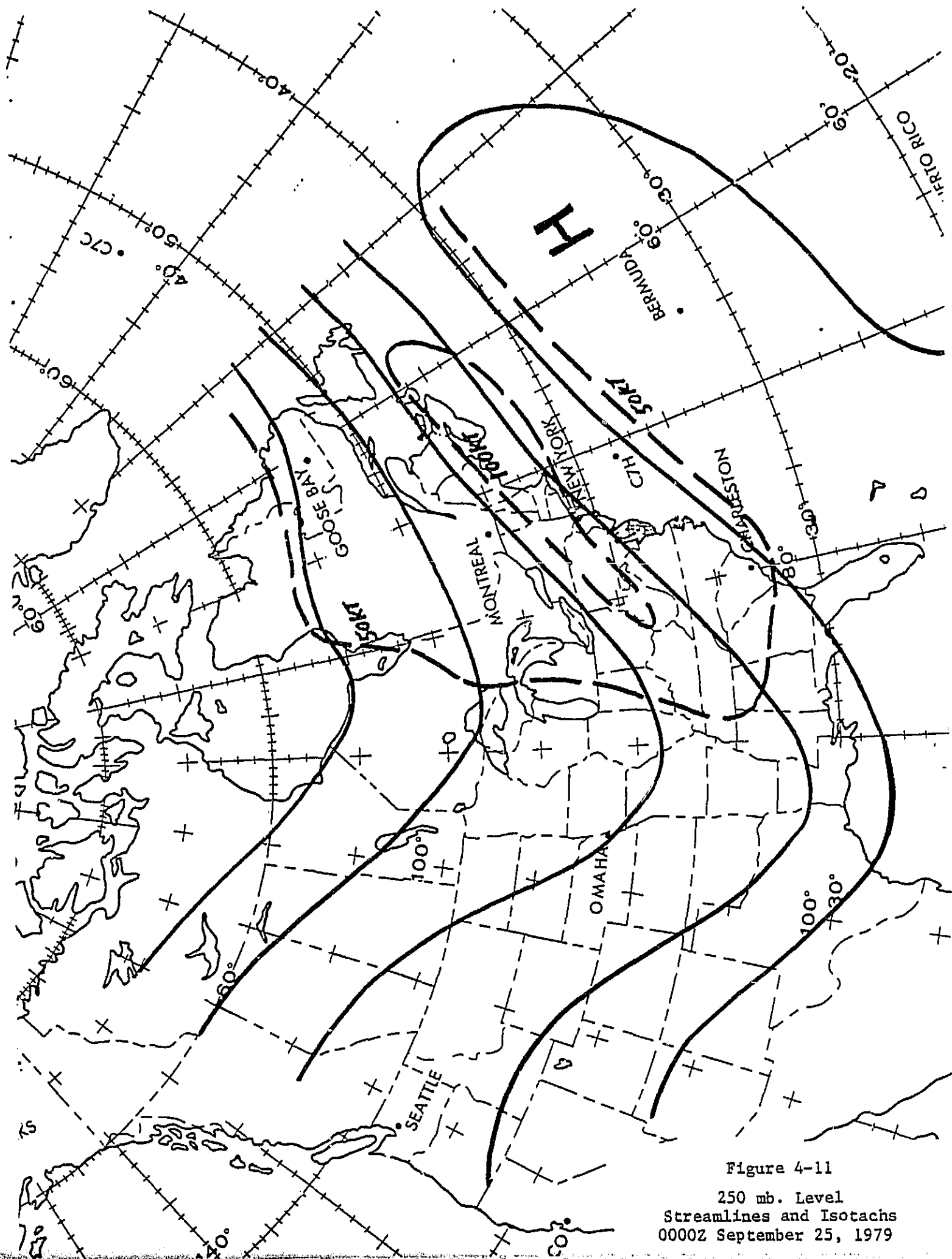


Figure 4-11

250 mb. Level
Streamlines and Isotachs
0000Z September 25, 1979

DATE: September 28, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 44 flights - 64 error segments
RED Airlines - 13 flights - 53 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Northern Italy, Southeastern France	330/20	45 to 60 deg.
Vicinity of Ireland	290/20 to 35	40 to 50 deg.
20W to 30W, 50W to 60N	180 to 190/65 to 90	10 to 35 deg. and 25 to 40 kts.
30W to 40W, 50N to 60N	160 to 260/30 to 45	30 to 60 deg. and 17 to 35 kts.
40W to 50W, 50N to 60N	270 to 290/40 to 85	30 to 10 deg. and 30 to 45 kts.
Southeastern Quebec and Newfoundland	270/110	20 to 25 kts.

BLUE Airlines Data

(North Atlantic segments consistent with above findings)

Vicinity of Greece, Eastern Mediterranean and Northern Egypt	260 to 290/10 to 55	20 to 40 deg., 15 to 25 kts. and 5 to 7°C
--	---------------------	--

DISCUSSION: Figure 4-12 presents streamlines and isotachs representative of the 250 mb. level at 00Z on September 29th.

The extensive area of wind forecast errors over the North Atlantic appears to be the result of unexpected development of the low south of Greenland. Reference to the previous 00Z analysis and forecast shows that this low deepened more

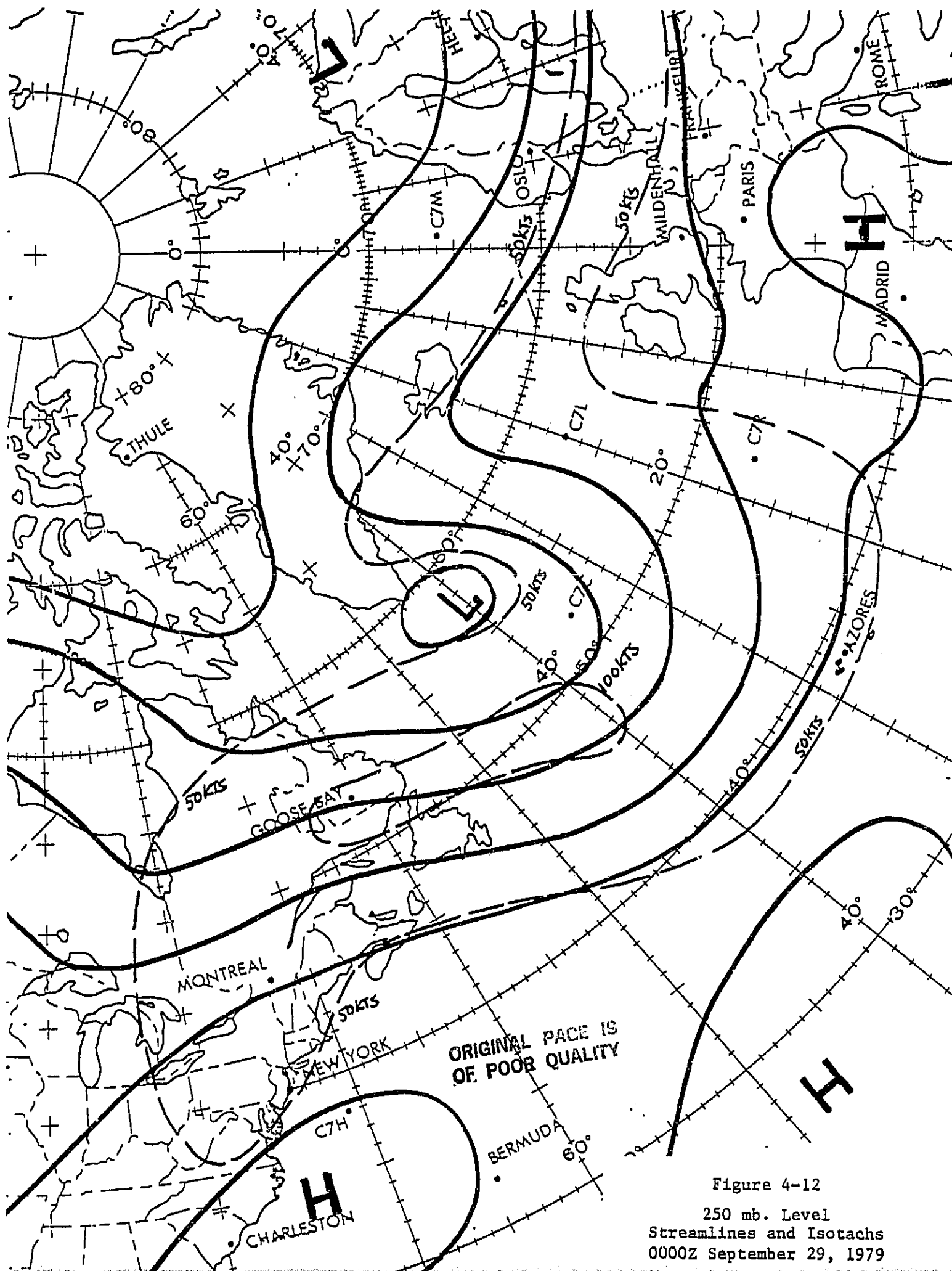


Figure 4-12
250 mb. Level
Streamlines and Isotachs
0000Z September 29, 1979

DATE: September 28, 1979 (Continued)

rapidly than expected. The 250 mb. forecast valid at 00Z on September 29th showed a trough in this region with a 250 mb. height value of 10,150 meters just south of Greenland. The actual analysis showed a closed-off low at this point within a 9,960 meter height contour. Some observations of easterly winds greater than 50 kts. were shown in southern Greenland. This error in the location and intensity of this low resulted in the wind direction errors over the British Isles and west to 20W, and in the direction and speed errors further west around the center of the low.

The wind speed forecast errors further to the west over eastern Canada appear to have been less related to the error in forecasting the development of the low. These errors of 20 to 35 kts. are more likely the result of the tendency to underforecast the maximum winds. The forecast valid at 00Z on the 29th showed a 70 kt. isotach in just about the same location as the 100 kt. isotach in Figure 4-12.

The forecast errors in eastern Europe, the Mid-East and North Africa are the result of the poorly defined flow around the weak high and low in Spain and the Mediterranean. The locations of the centers of the high and low were missed slightly by the forecast. The error was not significant but was sufficient to cause the wind direction errors noted.

DATE: October 5, 1979

Westbound Flow

DATA SOURCES: RED Airlines - 8 flights - 31 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Area Bounded by Quebec, Ottawa and New York	180/100 to 120	25 to 35 kts.
Vicinity of 55N50W	290/85 to 90	20 to 25 kts.
Area Between Ireland, 30W, 50N and 58N	090 to 180/20 to 65	30 to 130 deg. and 0 to 40 kts.

DISCUSSION: Figure 4-13 describes the approximate streamline and isotach fields that existed on October 5th. The figure was actually derived from the 12Z analysis of October 6th since the 00Z analysis was not available.

The situation that existed on October 5th and the reason for the forecast errors in the North Atlantic area was quite similar to the last day reviewed - September 28th. Here again the forecast valid at 00Z on October 6th shows a much less developed trough in the eastern Atlantic. As Figure 4-13 shows, the more developed, closed low at 20W resulted in more southeasterly and easterly winds in this area whereas the forecast with the less developed trough showed winds from the south to south-southwest.

The other two forecast error areas, in the vicinity of 50W and in the vicinity of New York, appear to be the result of misplacement and underforecast of the maximum wind areas in the ridge centered at 50W. The forecast did not show this ridge building as much and it showed an area of maximum winds bounded by a 90 kt. isotach through the ridge where Figure 4-13 shows winds of 100 kts. or more.

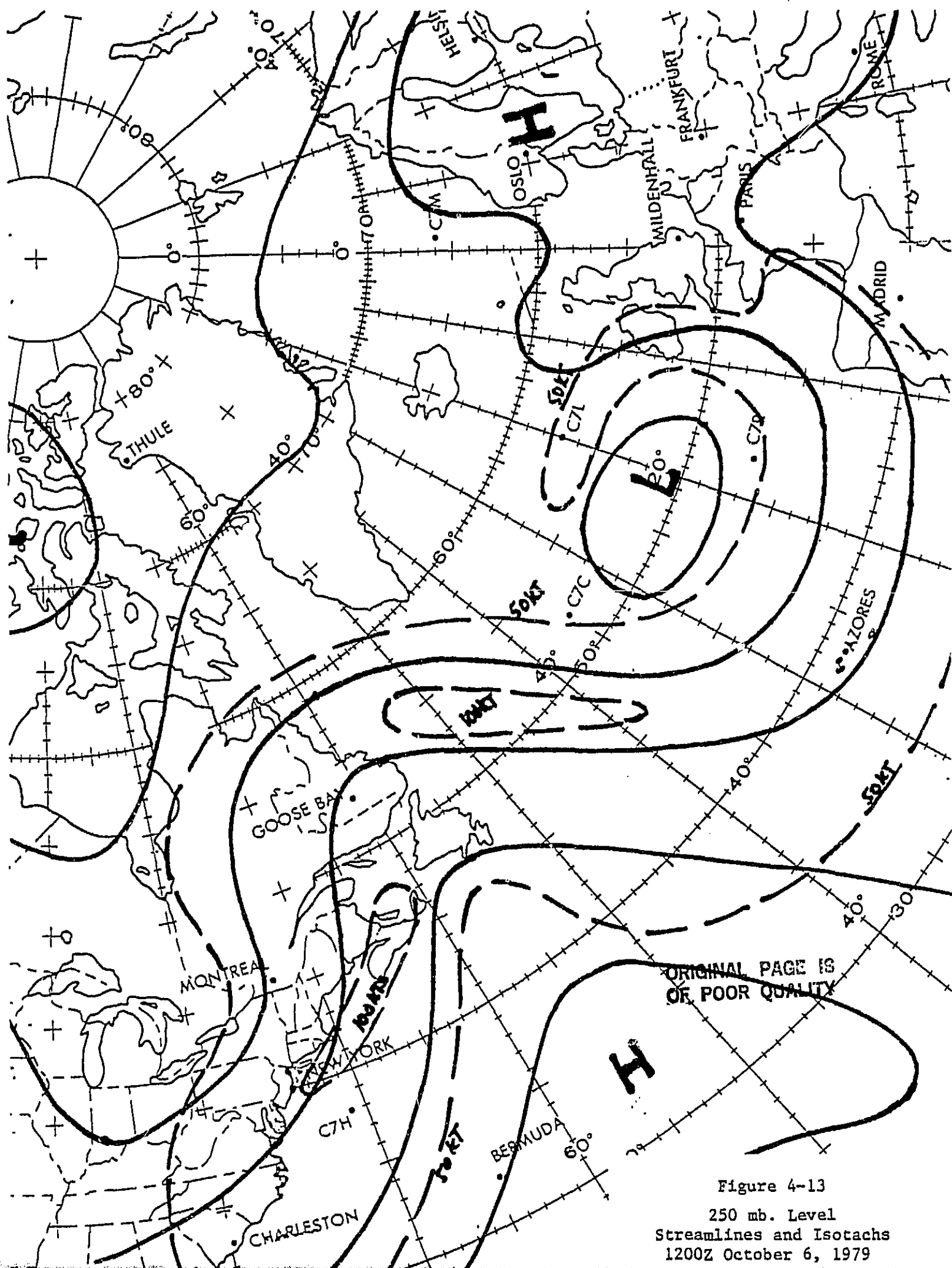


Figure 4-13
 250 mb. Level
 Streamlines and Isotachs
 1200Z October 6, 1979

DATE: October 8, 1979

Eastbound Flow

DATA SOURCES: BLUE Airlines - 18 flights - 33 error segments

FORECAST ERRORS:

BLUE Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Between 60W, 20W, 45N and 50N	260 to 290/85 to 110	10 deg. and 20 to 45 kts.
Vicinity of 52N15W	180 to 210/30 to 50	30 to 75 deg.
Over Iran, Pakistan	200 to 225/35 to 60	30 to 50 deg. and 15 to 30 kts.

DISCUSSION: Figure 4-14 depicts the approximate streamline and isotach fields for the 250 mb. level valid at 0000Z October 9th, which corresponds with the time most of the BLUE Airlines flights were operating.

The 250 mb. forecast valid at the same time was not available for review, but based upon the forecast valid at 12Z on October 8th, the NMC analysis valid at 00Z on October 8th, and an operational airline analysis valid at 00Z on October 9th, it appears that the forecast errors in the Mid Atlantic were the result of unexpected building of the ridge at 45W and deepening of the low at 20W.

Wind speeds were underestimated, as well, on both sides of the ridge at 45W. The 12Z forecast showed maximum isotachs of 90 kts. in just about the same locations as the 100 kt. isotachs in Figure 4-14. A small area southeast of Halifax was enclosed in a 110 kt. isotach.

From the data that were available, it appears that actual wind speeds in these areas were up to 140 kts.

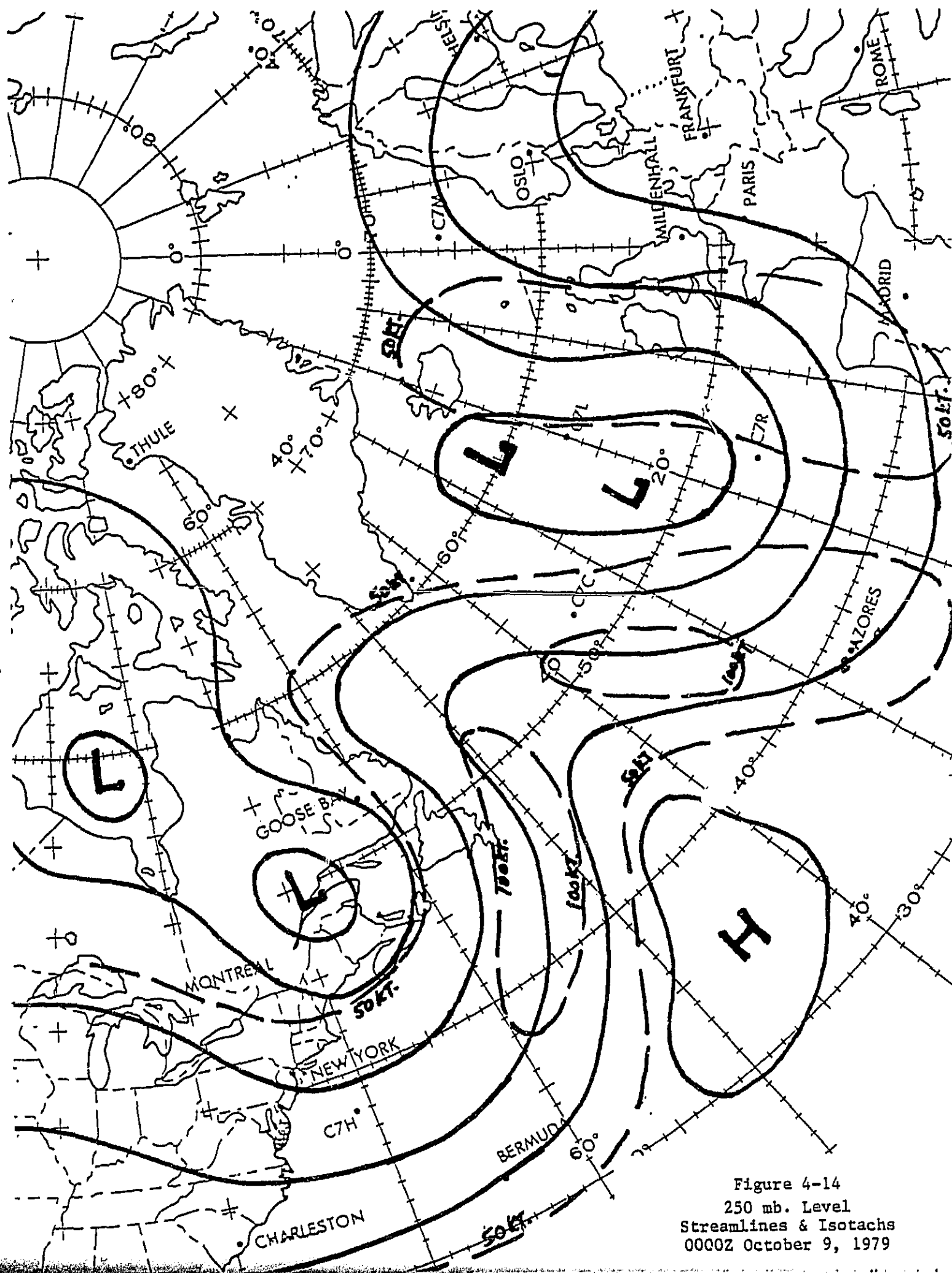


Figure 4-14
250 mb. Level
Streamlines & Isotachs
0000Z October 9, 1979

DATE: October 12, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 27 flights - 14 error segments
RED Airlines - 7 flights - 10 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Cartwright to 57N40W	230/70	25 kts.
Stornaway to 63N20W	260/35	0 to 40 deg. and 15 to 20 kts.

BLUE Airlines Data

Vicinity of 53N45W	250/105	15 deg. and 25 kts.
--------------------	---------	---------------------

DISCUSSION: No new figure is included to depict the winds on October 12th since the forecast errors listed above are few and proved to be relatively insignificant. Figure 4-14 may be used for general orientation since the situation at 250 mb. was similar on October 12th to that of October 9th. The low in the eastern Atlantic was deeper and centered at approximately 46N05W. The low in eastern Canada had also intensified while the Mid-Atlantic ridge had flattened somewhat.

The data which were available for review included only the 250 mb. analysis for 00Z October 12th, the forecast for 00Z of October 13th, and the analysis for 12Z of October 13th. From the data available, it is apparent that in a general sense the forecast appears to be quite accurate. Even the maximum wind speeds appear to be within 10 to 20 kts. of forecast.

The error segments that were found by RED and BLUE Airlines are widely scattered and of little operational significance.

DATE: October 15, 1979

Eastbound Flow

DATA SOURCES: BLUE Airlines - 21 flights - 34 error segments
RED Airlines - 9 flights - 45 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Newfoundland	240/85	22 kts.
20W to 40W Between 45N and 57N	-	7 to 11°C
British Isles, Western France and Adjacent Ocean East of 20W	340 to 360/30 to 110	20 to 120 deg. and 15 to 40 kts.

BLUE Airlines Data

50W to 30W Between 48N and 57N	230 to 250/95 to 115	10 to 20 deg., 15 to 40 kts. and 5 to 9°C
France and Spain	270 to 340/10 to 25	35 to 65 deg. and 10 to 15 kts.

DISCUSSION: Figure 4-15 depicts the approximate streamlines and isotachs at the 250 mb. level for 0000Z October 16th.

The only data that were available for review for this day were the 250 mb. NMC analysis valid at 00Z October 15th and an airline 250 mb. analysis valid at 00Z on October 16th. The only forecast data available were the NMC Trop and Vertical Wind Shear prog. valid at 00Z on October 15th and the winds and temperatures from the flight plan error segments. Therefore, it was not possible to make specific comments on the forecast errors.

It is apparent that the errors in the vicinity of the British Isles are related to the development and movement of the trough in that area. Some of the flight plan error

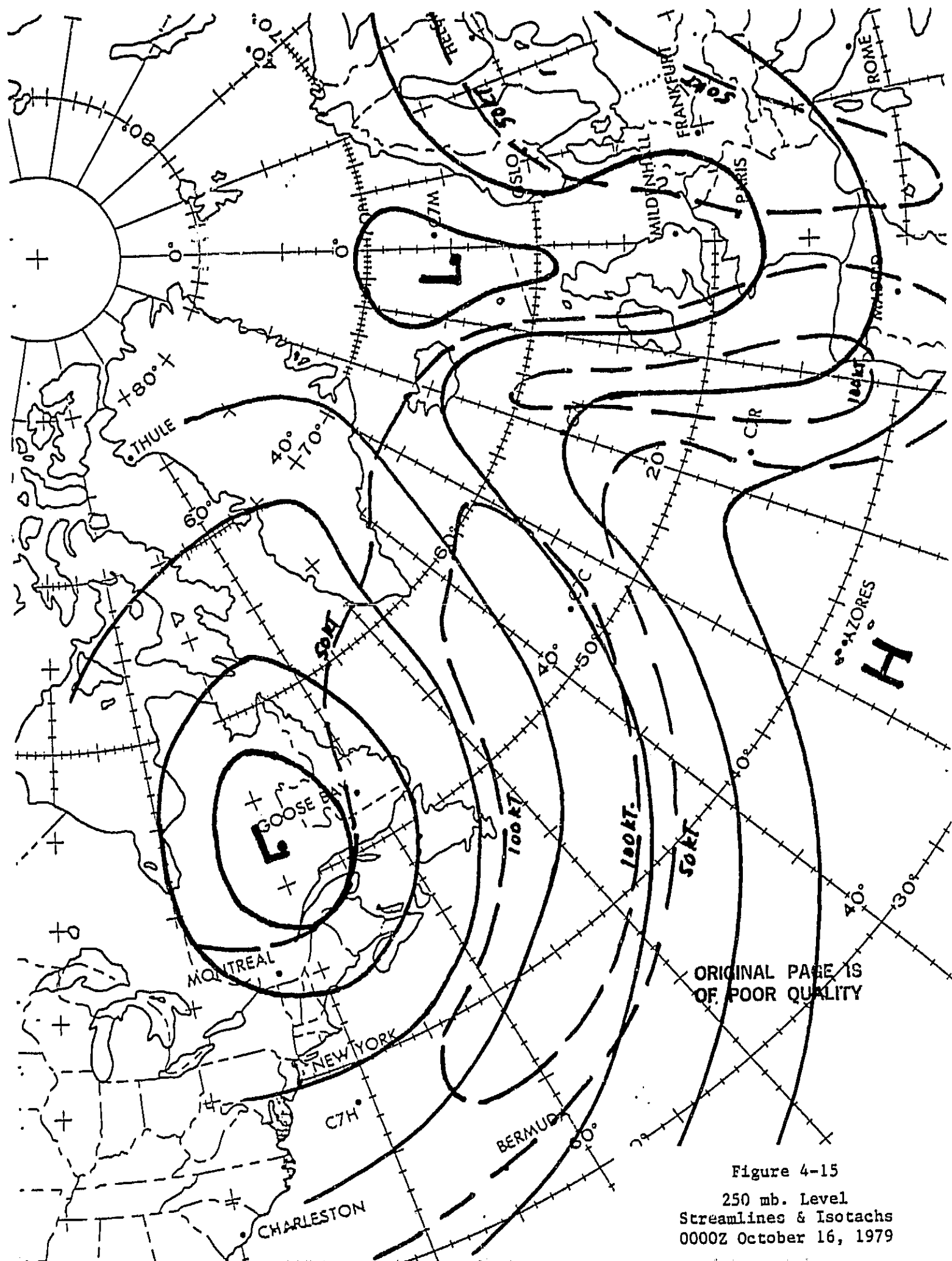


Figure 4-15
250 mb. Level
Streamlines & Isotachs
0000Z October 16, 1979

DATE: October 15, 1979 (Continued)

segments may be the result of time interpolation in this rapidly changing area.

Comparison of the RED and BLUE error segments in the Mid-Atlantic area indicates that they may also be partly the result of choice of prog. or time interpolation. The RED flights were mostly eastbound and the error segments mostly occurred east of 40W. They were mostly temperature errors. The BLUE flights were also mostly eastbound but the error segments occurred between 50W and 30W and were mostly wind speed errors.

DATE: October 19, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 29 flights - 25 error segments
RED Airlines - 6 flights - 18 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Vicinity of 53N50W	330/150	30 kts.
20W to 30W, 50W to 60N	180 to 220/65 to 85	25 to 30 kts.
England and North Sea	090 to 140/25 to 35	40 to 70 deg.

BLUE Airlines Data

Austria Vicinity	030/60	30 deg. and 10 kts.
Iran, Iraq Vicinity	220 to 300/20 to 60	10 to 45 deg. and 20 to 45 kts.

DISCUSSION: No figure is included to describe the wind and temperature fields for October 19th. After reviewing the available forecast and analysis data it was determined that the forecast was actually quite accurate and the error segments above were either insignificant or not confirmed by the forecast data.

A weak trough fluctuated aimlessly about eastern Europe resulting in rapidly varying wind directions and causing the BLUE Airlines error segments.

In the North Atlantic area, the analyses and forecasts valid at 00Z on October 19th and 20th were almost identical, and the absence of any error segments on five westbound BLUE Airlines flights partially confirms this. The RED Airlines error segments were all from eastbound flights which presumably operated 12 hours later, were relatively small errors in segments around a Mid-Atlantic trough, and could likely have been partly the result of time interpolation or the choice of prog. on which the flight plans were based.

DATE: October 26, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 20 flights - 18 error segments
RED Airlines - 5 flights - 15 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Maine, New Brunswick, and Southern Quebec	220 to 230/60 to 90	10 deg. and 20 to 30 kts.
British Isles	Variable/10 to 30	30 to 45 deg. and zero to 10 kts.

BLUE Airlines Data

Vicinity of 63N15W	200 to 210/60 to 80	35 deg. and 20 to 30 kts.
Eastern Europe and Middle East Through Austria, Greece, Turkey, Iraq and Iran	220 to 300/20 to 55	10 to 45 deg. and 10 to 45 kts.

DISCUSSION: Figure 4-16 depicts the approximate streamlines and isotachs for 0000Z on October 27th.

The high and low over Europe resulted in relatively light and variable winds and poorly defined flow, and account for most of the error segments listed above.

All of the RED and BLUE flights were westbound and tended to be north of the maximum winds, where the forecast errors were insignificant, until they reached eastern Canada. Even though there were no flight plan error segments there to confirm it, a more significant forecast error occurred to the south in the area of maximum winds. The forecast called for maximum winds between 90 and 110 kts. in an area approximately identical in width to the area enclosed by the 100 kt. isotach in Figure 4-16 but extending further down into

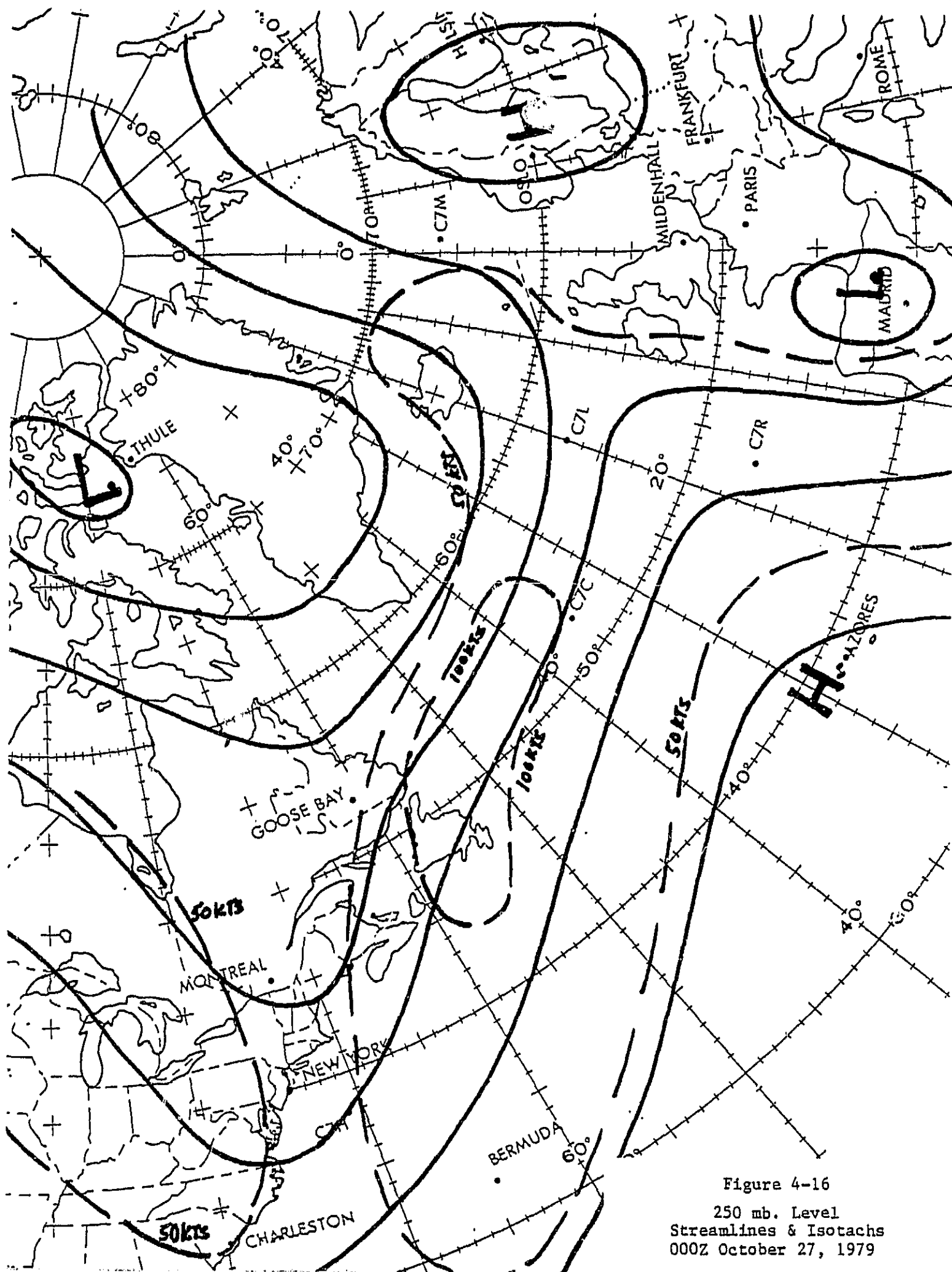


Figure 4-16
 250 mb. Level
 Streamlines & Isotachs
 000Z October 27, 1979

DATE: October 26, 1979 (Continued)

the trough across Nova Scotia to about 40N68W. Actual winds in this area were over 100 kts. with a number of winds of 130 to 155 kts. observed.

DATE: November 2, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 31 flights - 42 error segments
RED Airlines - 3 flights - 20 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Southern Ontario and Great Lakes Area	230/98 to 105	20 to 40 kts.
52N50W	270/110	22 kts.
Area Bounded by 49N40W, 51N20W, 55N05W and 61N10W	220 to 240/70 to 160	10 to 40 deg. and 20 to 55 kts.
Eastern France Through Italy to Greece	280 to 360/45 to 130	0 to 60 deg. and 0 to 35 kts.

BLUE Airlines Data

(Segments consistent with findings above for North Atlantic Ocean areas.)

Western France Through Spain	360 to 040/60 to 95	15 to 20 deg and 20 to 25 kts.
Through Belgium, Germany, Eastern France, and Italy	340 to 010/85 to 125	15 to 30 deg. and 15 to 35 kts.
Vicinity of Iran	150 to 220/15 to 25	50 to 100 deg. and 10 to 15 kts.

DISCUSSION: The approximate wind field over the North Atlantic North America and Europe at 0000Z on November 3rd is depicted by 250 mb. level streamlines and isotachs in Figure 4-17.

The only data which were available to explain the forecast errors listed above were the NMC 250 mb. analysis and forecast valid at 0000Z on November 2nd, the 250 mb. analysis

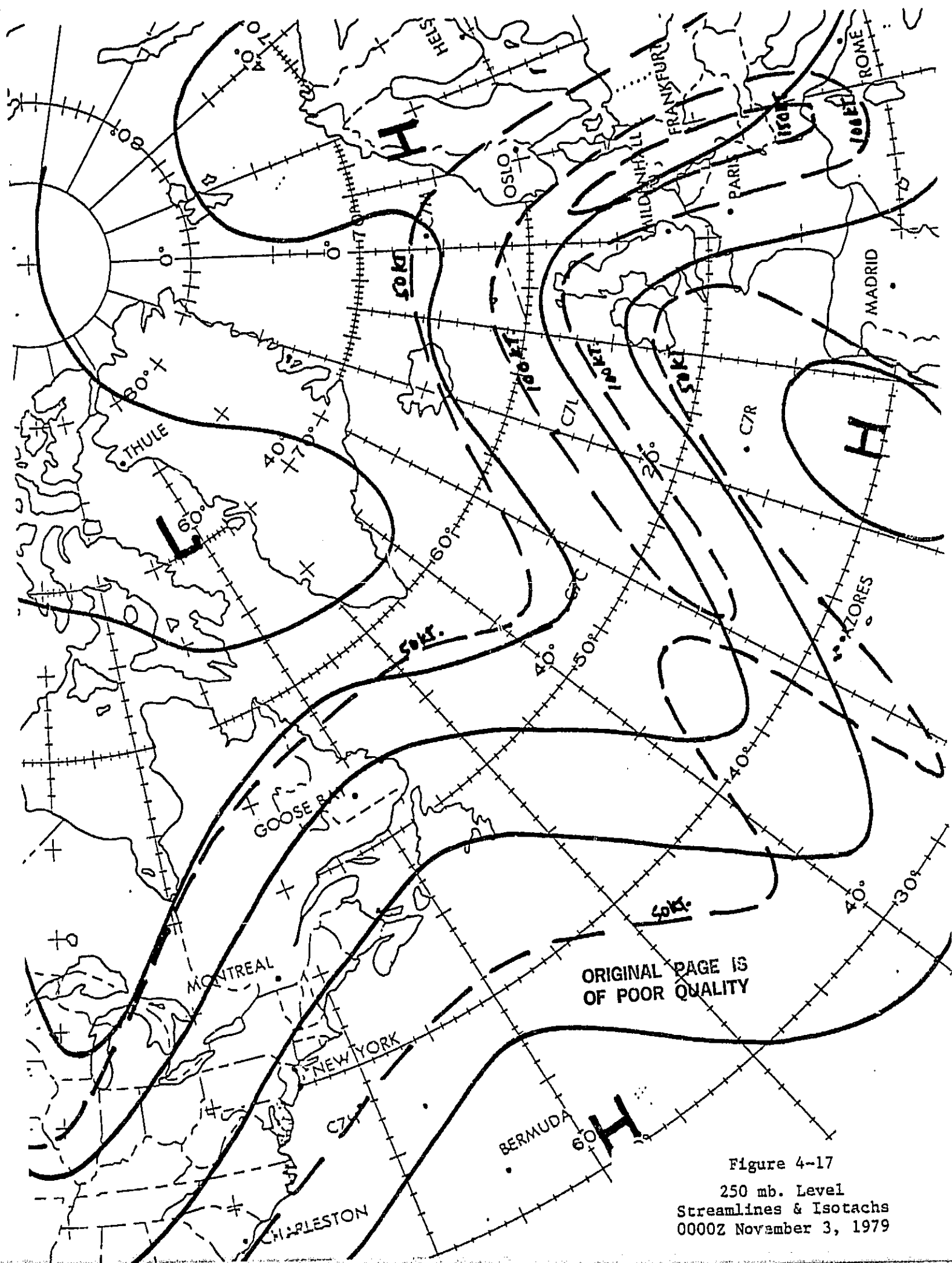


Figure 4-17
 250 mb. Level
 Streamlines & Isotachs
 0000Z November 3, 1979

DATE: November 2, 1979 (Continued)

valid at 1200Z on November 3rd, and the 250 mb. forecast valid at 0000Z on November 3rd.

Most of the westbound flights which observed the error segments listed above would have been operating between 1200Z and 1800Z on November 2nd, in between the time periods for which data were available. As a result, it is suspected that some of the forecast errors, especially those over the western Atlantic and North America, were caused by time interpolation or choice of prog. since the forecast appears to be quite accurate in these areas.

The extensive area of wind speed errors in the eastern Atlantic, and direction and speed errors over Europe are the result of underestimated wind speeds throughout the ridge and a slightly more than expected building of the ridge. The forecast showed an area of maximum winds on the west side of the ridge enclosed by a 110 kt. isotach which extended from 30W to 20W and from about 50N to 57N at its point of maximum width. The maximum wind decreased to 70 kts. at the top of the ridge and increased to 90 kts. on the east side of the ridge over the North Sea and down into Belgium and France. Reference to Figure 4-17 shows that significantly stronger winds were observed throughout the ridge. Maximum winds of 125 kts. were observed on the west side and through the top of the ridge while winds of 150 to 165 kts. were found on the east side.

DATE: November 5, 1979

Eastbound Flow

DATA SOURCES: BLUE Airlines - 28 flights - 2 error segments
RED Airlines - 2 flights - 24 error segments

(All data from eastbound RED Airlines flights were discarded for this day. See Task I report.)

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Boston to Halifax	260 to 270/50 to 80	0 to 21 kts. and 7°C
50W to 30W, 45N to 50N	270 to 280/65 to 85	50 to 60 deg. and 15 to 25 kts.
30W to 10W, 48N to 52N	220 to 240/20 to 75	30 to 45 deg., 5 to 60 kts. and 5°C
Southern England and Northern France	240 to 270/25	30 to 65 deg., 50 to 85 kts. and 5 to 6°C

BLUE Airlines Data

Southwestern France	300/45	25 kts.
---------------------	--------	---------

DISCUSSION: Upon review of the NMC 250 mb. forecast valid at 0000Z on November 6th and an operational airline analysis for that time it became apparent that the forecast for this day was highly accurate. No BLUE Airlines error segments were found, further confirming the accuracy of the forecast. While the relatively minor RED Airlines error segments in the western Atlantic and on the East Coast of North America appear to be legitimate, those on the eastern side of the ocean and in Europe were not consistent with the NMC forecast data or the analysis and it was assumed that this day was erroneously identified as having forecast errors.

DATE: November 9, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 42 flights - 21 error segments
RED Airlines - 13 flights - 10 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Between Madrid and 41N20W	320/56 to 76	25 to 35 deg. and 25 to 35 kts.
Switzerland, Eastern France	240/88	17 deg. and 23 kts.
Along a Line from Detroit to Montreal	240/121 to 127	10 deg., 22 kts. and 10°C

BLUE Airlines Data

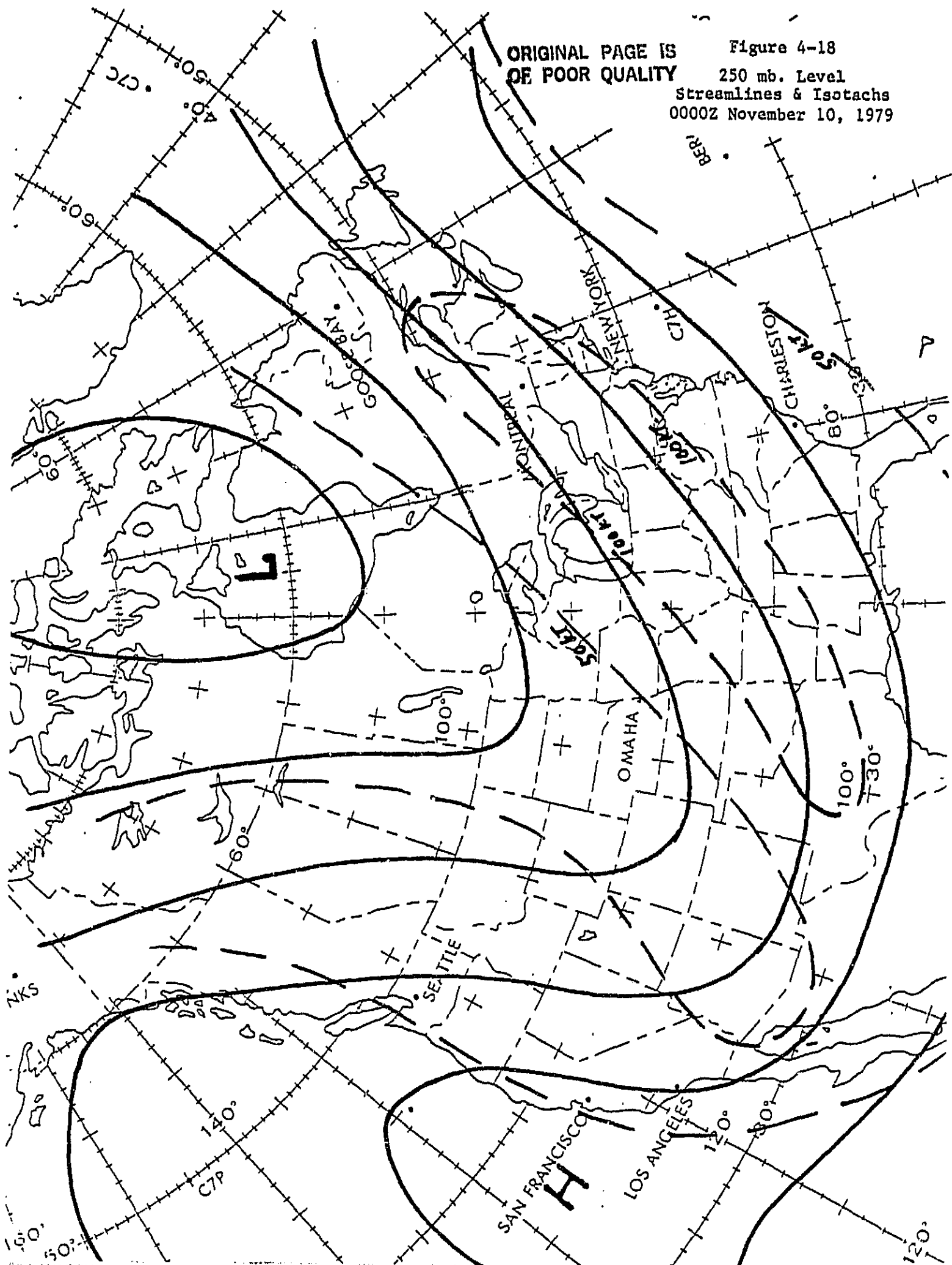
Between Seattle and Los Angeles	340/52	32 deg. and 15 kts.
Southern Ontario, Western New York	250/121	25 kts.
Eastern U.S. Approxi- mately Along a Line From Houston to Montreal	240 to 250/125	25 kts.
Southwestern Spain	290/50	23 deg. and 32 kts.

DISCUSSION: Figures 4-18 and 4-19 describe the approximate wind fields over the United States and Europe at 0000Z on November 10, 1979.

While the NMC analysis and forecast valid at that time were not available for review, those for 00Z on November 9th and 1200Z on November 10th were. These data show that the ridge off the West Coast of the U.S. was in the process of flattening throughout this period while the trough to the east of

ORIGINAL PAGE IS
OF POOR QUALITY

Figure 4-18
250 mb. Level
Streamlines & Isotachs
0000Z November 10, 1979



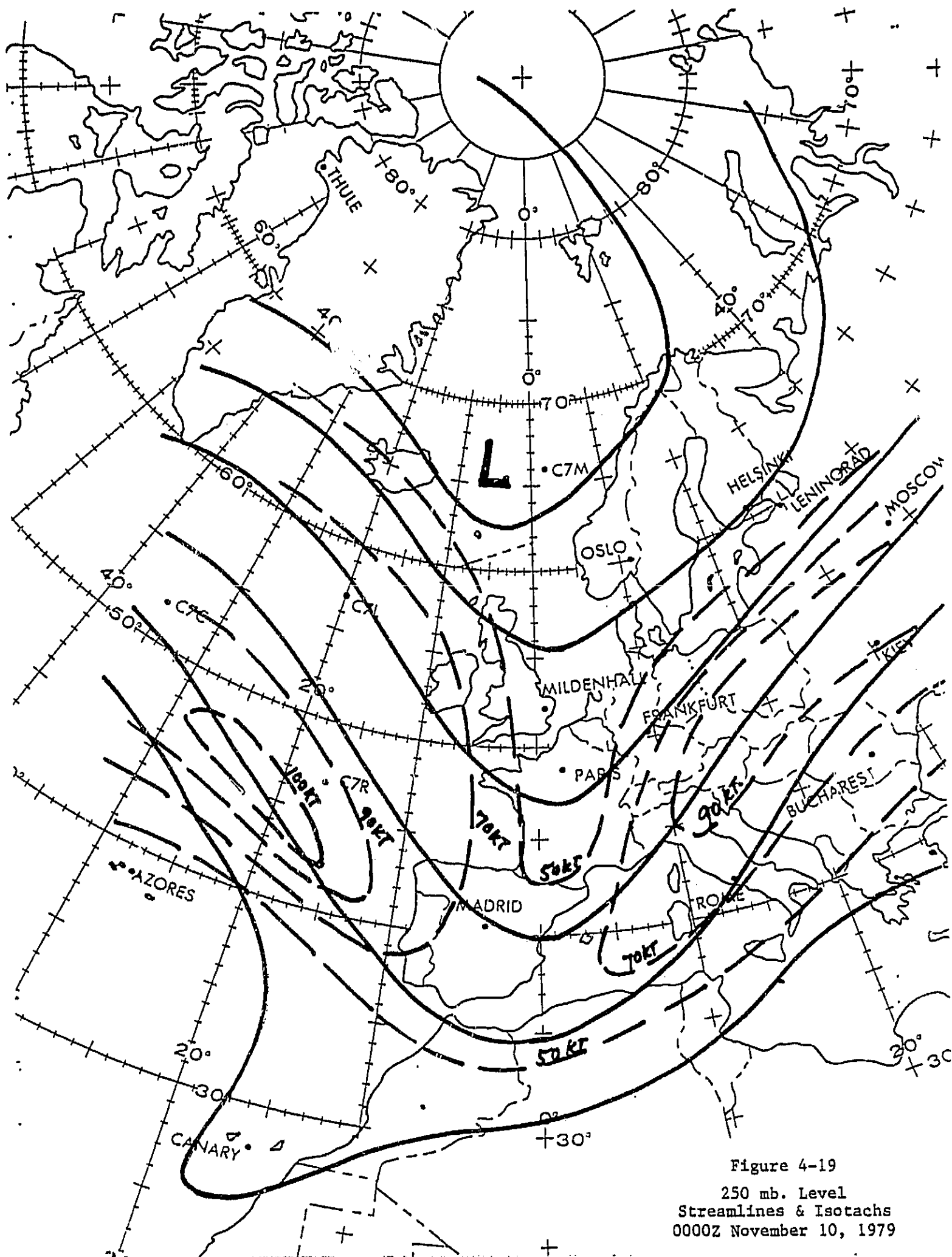


Figure 4-19
 250 mb. Level
 Streamlines & Isotachs
 0000Z November 10, 1979

DATE: November 9, 1979 (Continued)

it was intensifying. This likely caused the relatively minor errors in wind direction and speed that were noted between Seattle and Los Angeles.

The 00Z data for November 9th show a more extensive area of forecast error over the eastern half of the U.S. The forecast showed maximum winds enclosed by a 70 kt. isotach that extended from Minnesota through Iowa, Missouri, Tennessee and North Carolina. The analysis showed winds of 100 to 130 kts. extending from Texas up through New England and 70 kt. winds down into the Gulf Coast, similar to Figure 4-18. By 1200Z of November 10th the forecast was for winds above 110 kts. in an area extending from Kentucky and Indiana up through southeastern Quebec and, as Figure 4-18 shows, was quite accurate. The plans which resulted in the error segments listed above were based on forecasts valid during the intervening hours.

Figure 4-19 shows that western Europe was dominated by a trough centered along 00W. The figure includes 70 kt. and 90 kt. isotachs to show the sharp gradient of the wind speeds on both sides of the trough where the forecast errors occurred. Since review of the NMC forecasts and analyses show that the forecasts were nearly perfect in this region, it is suspected that the error segments noted above could be the result of the airline data interpolation schemes in areas where the wind speed gradient is sharp. In these areas the wind speeds at adjacent Marsden Square data points can differ by 50 to 100 kts. and it is possible that errors of the magnitude noted above (10 to 35 degrees and 15 to 35 kts.) can result from the algorithm used to determine segment average winds.

DATE: November 12, 1979

Eastbound Flow

DATA SOURCES: BLUE Airlines - 33 flights - 8 error segments
RED Airlines - 6 flights - 40 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Nova Scotia, Newfoundland	240 to 270/5 to 35	30 to 125 deg. and 0 to 35 kts.
50W to 20W, 55N to 60N	150 to 210/20 to 70	50 to 150 deg. and 15 to 25 kts.
British Isles and France	090 to 190/20 to 50	70 to 80 deg., 0 to 20 kts. and 5 to 7°C

BLUE Airlines Data

55N20W to 55N40W	27/125	20 to 25 kts.
------------------	--------	---------------

DISCUSSION: Review of the NMC 250 mb. forecasts valid at 1200Z on November 12th and 0000Z on November 13th, and the Delta Airlines analysis valid at 0000Z on the 13th revealed that the RED Airlines segments above were erroneously identified as errors. All the RED Airlines flight plan winds throughout the North Atlantic were from the south, southeast or east and few were stronger than 30 kts. The BLUE Airlines data, the forecast and the analysis all showed westerly winds of over 100 kts. in this area.

Disregarding the erroneous RED Airlines data, the remainder of the data showed that the forecast was very good except for a small area at the center of the maximum winds as indicated by the BLUE Airlines data. The 00Z forecast called for maximum winds greater than 130 kts. in the area bounded approximately by 60W, 55N, 30W and 50N. Several observations of 155 kts. were recorded in this area and the three BLUE Airlines error segments in this area were only off by 21 to 25 kts. These were judged to be relatively insignificant errors.

DATE: November 16, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 34 flights - 10 error segments
RED Airlines - 10 flights - 56 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
Through England and France	340 to 360/105 to 130	20 to 50 kts.
Along a Line From Cork to 49N20W to 47N30W to 46N40W	240 to 300/35 to 95	15 to 20 deg., 20 to 32 kts. and 6°C
Area Bounded by 57N, 63N, 10W and 40W	240 to 280/70 to 130	10 to 20 deg. and 30 to 50 kts.

BLUE Airlines Data

Vicinity of 53N35W	260/135	23 kts.
Vicinity of 60N25W	250/105	25 kts.
Switzerland, Italy and Eastern Mediterranean	200 to 220/70 to 90	15 to 40 deg., 20 to 30 kts. and 6°C
Turkey, Iraq and Iran	240/60 to 80	35 to 40 kts.

DISCUSSION: Figure 4-20 is an estimation of the winds that existed at 0000Z on November 17th when most of the flights above were operating. NMC 250 mb. analyses and forecasts were only available for 0000Z on November 16th and 1200Z on November 17th.

During the 36-hour period between 00Z on the 16th and 12Z on the 17th several changes were occurring relatively rapidly. The center line of the trough in the western Atlantic moved from 80W to 60W, the ridge extending from the Azores high

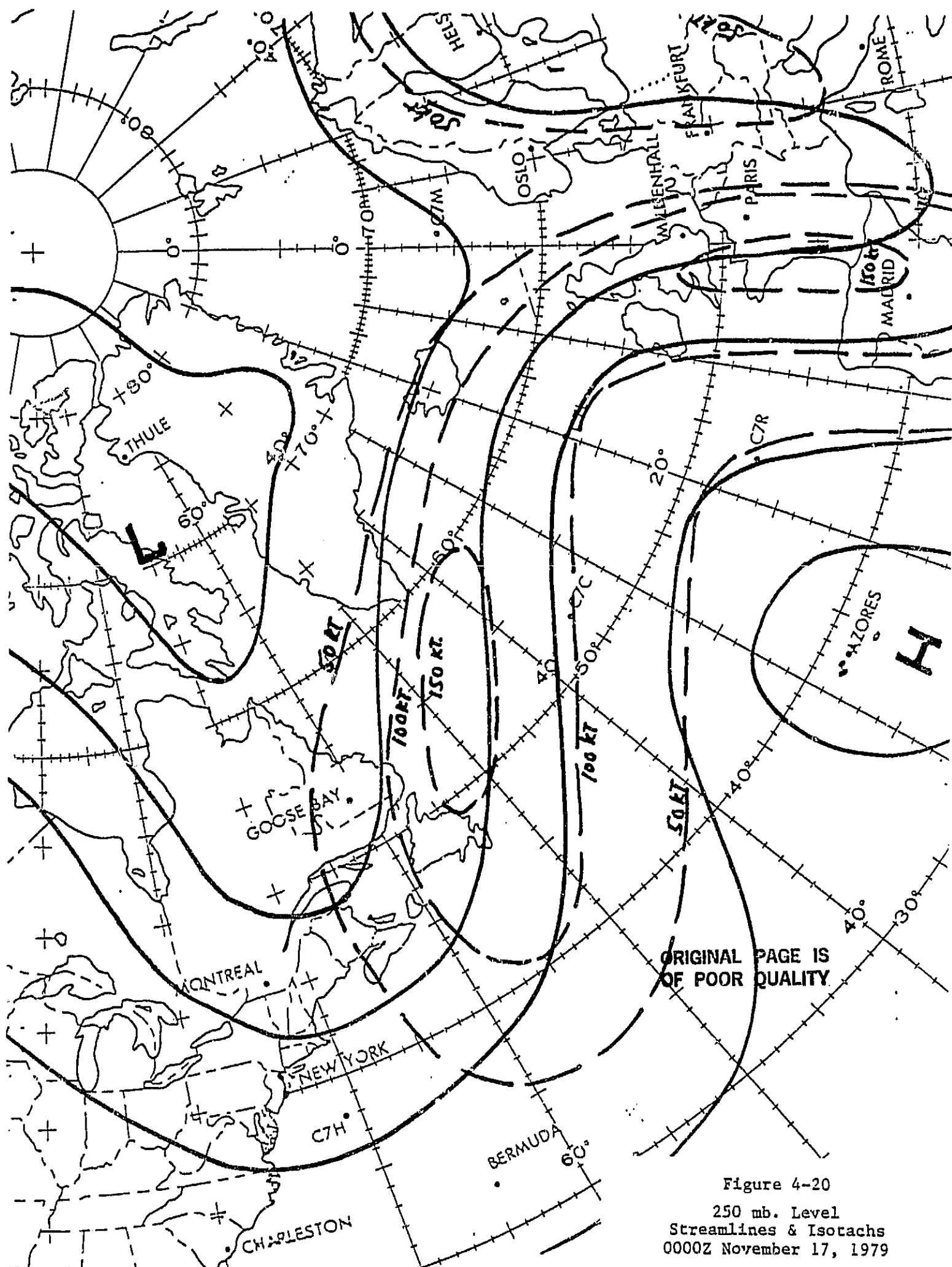


Figure 4-20
250 mb. Level
Streamlines & Isotachs
0000Z November 17, 1979

DATE: November 16, 1979 (Continued)

moved from a straight north-south orientation to a line from the Azores to Northern France, and the trough over Europe moved about 12 to 15 degrees eastward. The intervening location of these features during the time RED and BLUE Airlines flights were operating can only be estimated.

Despite the rapid changes, 12 BLUE Airlines flights across the Atlantic encountered only three error segments in the areas shown above, and six more in the Switzerland, Italy, eastern Mediterranean area. Again despite the rapid changes, both forecasts were quite accurate in locating these features. It is difficult to explain why there were numerous RED Airlines error segments under the same conditions, and so few BLUE Airlines error segments. The errors were confirmed, however, by review of the NMC data. The forecasts showed maximum wind isotachs of 130 kts. in the same relative locations as the 150 kt. isotachs in Figure 4-20. The analysis showed extensive areas of wind stronger than 150 kts. in these regions and a number of winds of 180 to 190 kts. were observed both on the west side of the ridge and over Western France and Spain as well.

DATE: November 19, 1979

Eastbound Flow

DATA SOURCES: BLUE Airlines - 34 flights - 8 error segments
RED Airlines - 12 flights - 11 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
51N15W to Cork to London	330 to 360/30 to 50	30 deg. and zero to 15 kts.
Vicinity of 56N20W	230/75 to 115	26 to 30 kts.

BLUE Airlines Data

Vicinity 54N30W	230/90 to 95	21 to 27 kts.
-----------------	--------------	---------------

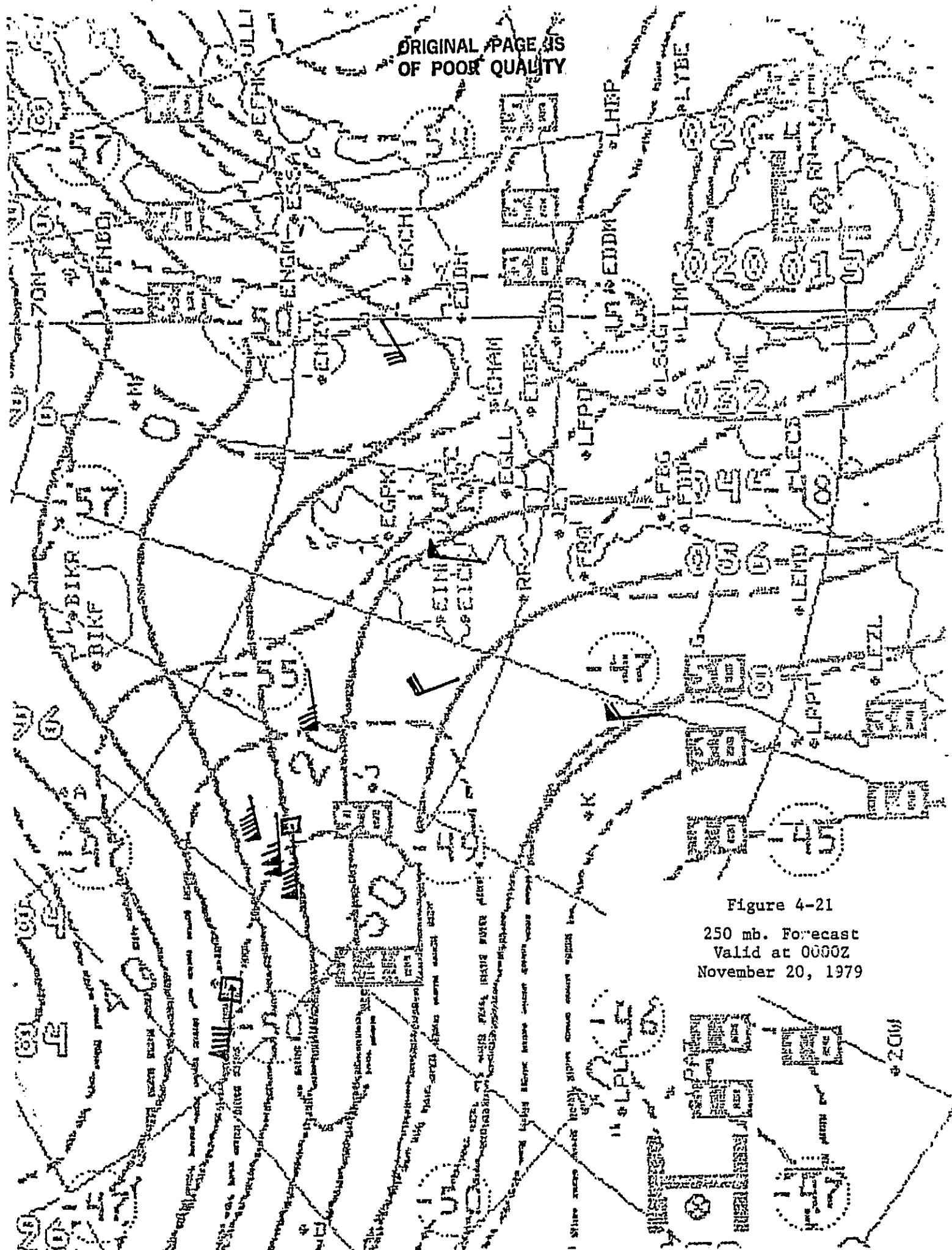
DISCUSSION: Review of the NMC 250 mb. forecast valid at 0000Z November 20th, an airline 250 mb. analysis valid at the same time, and the flight plan error segments listed above suggested that the forecast was actually quite accurate. The number of error segments was small and they missed the error criteria by small amounts.

Figure 4-21 is a copy of a portion of the NMC 250 mb. forecast valid at 0000Z November 20th. Wind barbs in the figure represent segment winds from flight plans on the analysis that were included as error segments from Task I. The wind barbs in boxes were from BLUE Airlines flights.

It is apparent from Figure 4-21 that the forecast errors on this day were relatively insignificant.

The wind barbs in the figure also give an example of an inconsistency that was found to be typical throughout the Task IV analysis. Note that between 20W and 30W a BLUE Airlines error segment indicated that the actual wind was 230/95. The identical RED Airlines segment (the locations of the segments are actually identical but the wind barbs were separated for clarity) indicated a wind of 230/115. Since a 90 kt. isotach passes through the center of the

ORIGINAL PAGES
OF POOR QUALITY



DATE: November 19, 1979 (Continued)

segment, the BLUE Airlines wind obviously is within the 20 kt. error criterion. However, since it was identified as an error segment, a difference greater than 20 kts. must have existed and since the actual wind is in agreement, the wind on the forecast flight plan must have differed by more than 20 kts. The same comment applies to the BLUE Airlines wind barb between 40W and 30W which is nearly on the 90 kt. isotach.

These data show two inconsistent findings. First, the segment winds on the flight plan on the actual weather developed by the RED and BLUE Airlines differed by 20 kts. even though they were developed for the same segment and from the same weather data. Second, the BLUE Airlines segment winds on the forecast flight plan must have been 230/68 and 230/70 for the 40W to 30W and 30W to 20W segments, respectively, neither of which seems consistent with the forecast depicted in Figure 4-21.

DATE: November 23, 1979

Westbound Flow

DATA SOURCES: BLUE Airlines - 44 flights - 28 error segments
RED Airlines - 14 flights - 35 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
British Isles, North Sea and Northern France	230 to 240/65 to 90	10 to 40 deg. and 25 to 45 kts.
Vicinity Quebec City	270/75	10 deg. and 25 kts.
Vicinity of Hopedale, Labrador	330/75	10 deg. and 25 kts.

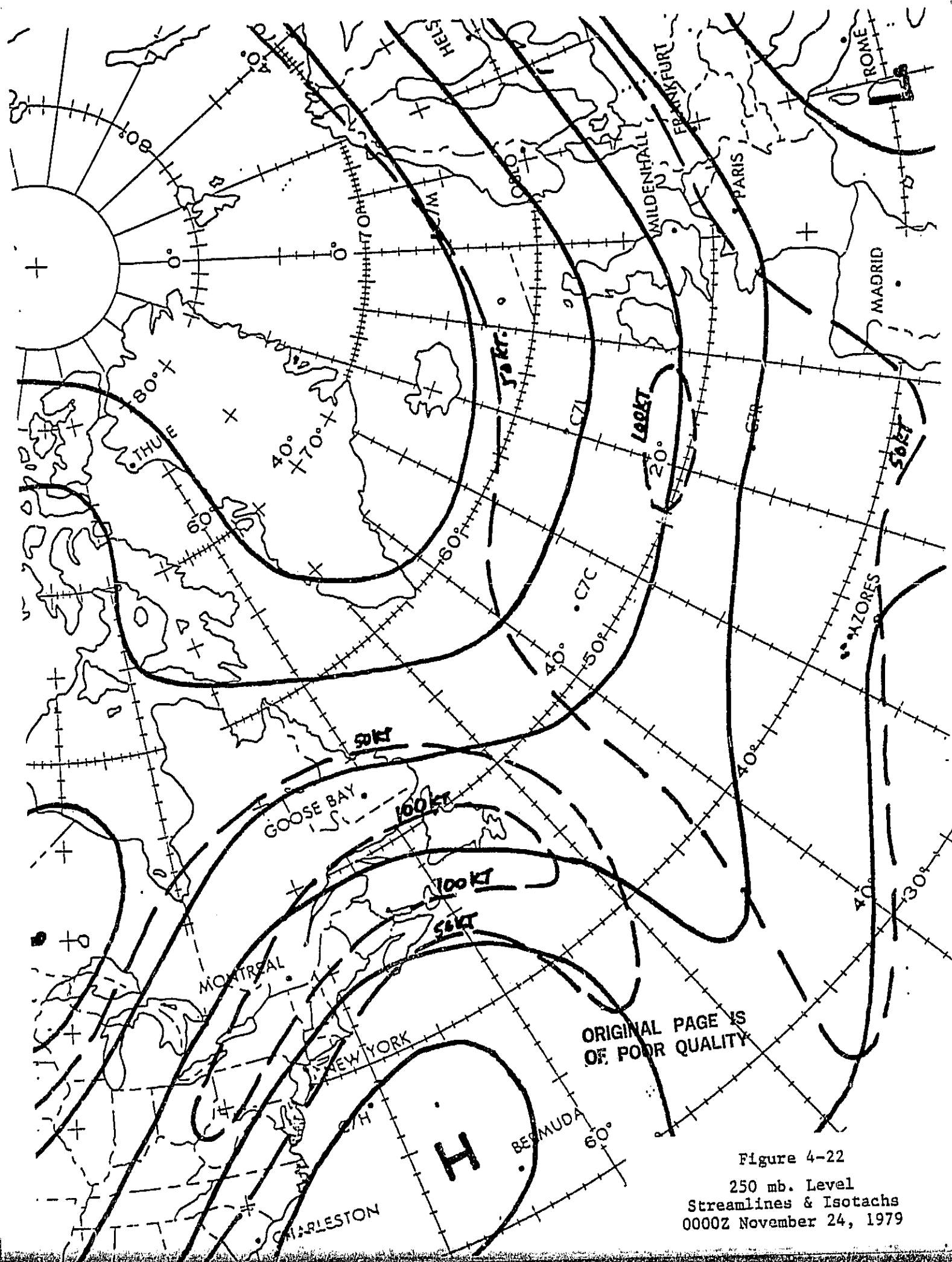
BLUE Airlines Data

Through Germany, Switzerland, Italy and Eastern Mediterranean	220 to 290/20 to 35	30 to 45 deg.
--	---------------------	---------------

DISCUSSION: Figure 4-22 depicts the approximate streamlines and isotach field at 0000Z on November 24, 1979.

The relevant data that were available to review the significance of the above forecast errors consisted of the 0000Z 250 mb. analysis for November 23rd, the 1200Z analysis for November 24th and the 0000Z forecast for November 24th. Since most of the flights that observed the above forecast errors operated between 1200Z on the 23rd and 0000Z on the 24th, the flight plan segment winds were likely developed on forecasts and analyses with valid times between those just mentioned. As such it is difficult to explain exactly how the forecast errors listed above occurred.

It appears that the wind direction and speed errors in Europe were related to the varying development of the low near Italy and the trough extending from that low which was



ORIGINAL PAGE IS
OF POOR QUALITY

Figure 4-22
250 mb. Level
Streamlines & Isotachs
0000Z November 24, 1979

DATE: November 23, 1979 (Continued)

centered approximately along 30E at 0000Z on the 23rd, 5W on the 24th 0000Z forecast, and 5E on the 24th 1200Z analysis.

Although no forecast error segments were encountered in the Mid-Atlantic area, review of the available data indicates that wind speeds were underestimated across the North Atlantic as well as through the ridge on the East Coast of North America. To the extent that it can be established from the available analyses, it appears that maximum winds of 100 to 110 kts. were observed in the small area west of Ireland and winds of 115 to 125 kts. were observed within the larger 100 kt. isotach area in the East Coast ridge. The 0000Z forecast for the 24th showed only a small area of 70 kt. winds centered about 50N30W and a small area of 110 kt. winds at the top of the ridge.

DATE: November 26, 1979

Eastbound Flow

DATA SOURCES: BLUE Airlines - 26 flights - 5 error segments
RED Airlines - 7 flights - 37 error segments

FORECAST ERRORS:

RED Airlines Data

<u>Location</u>	<u>Wind</u>	<u>Error</u>
New Brunswick, Nova Scotia and Newfoundland	-	6 to 7°C
British Isles, France and Adjacent Ocean East of 20W	340 to 020/60 to 105	10 to 30 deg. and 20 to 40 kts.
Vicinity of 50N to 55N at 30W	Variable/5 to 30	30 to 110 deg.

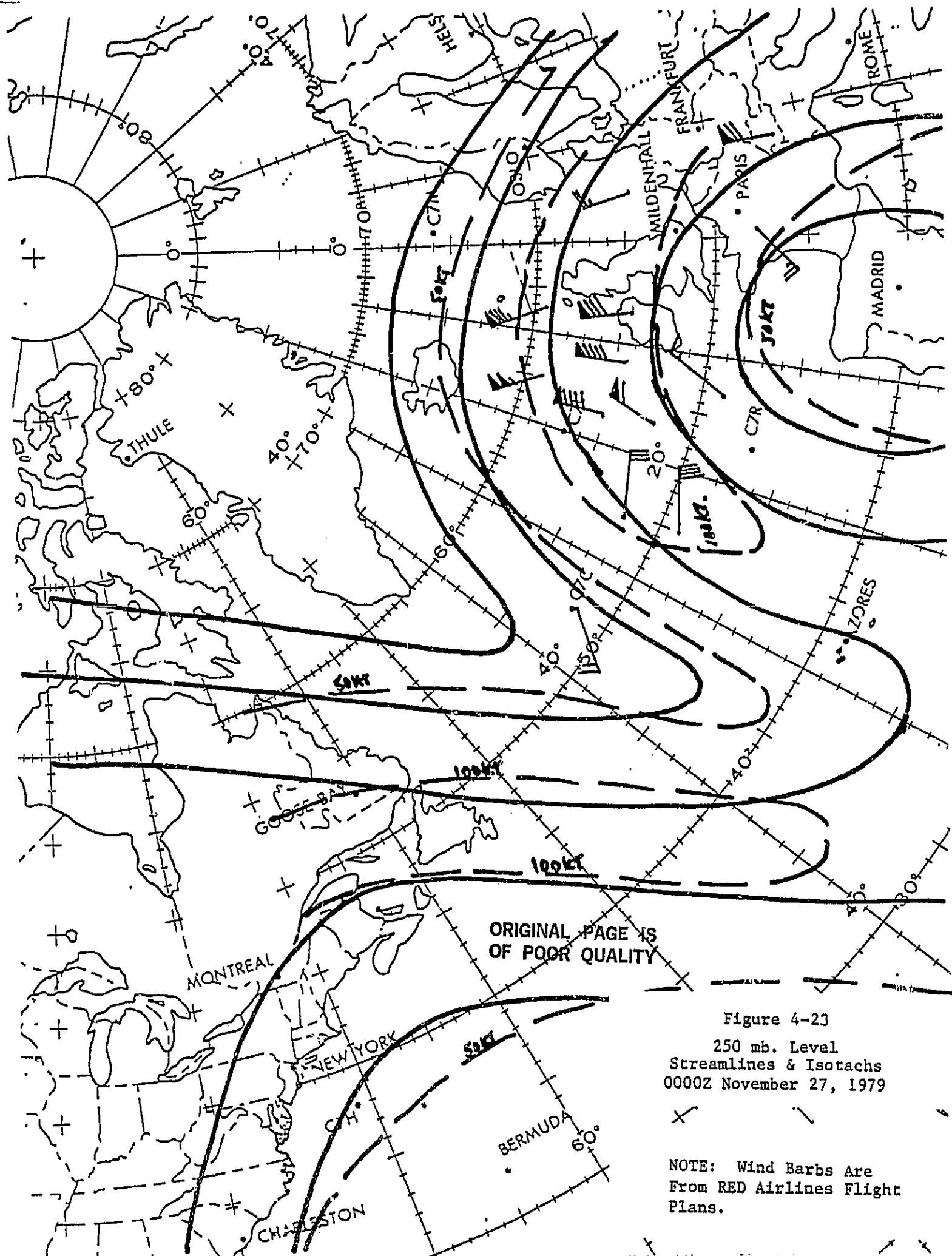
BLUE Airlines Data

Vicinity of 53N15W	210/105	21 kts.
--------------------	---------	---------

DISCUSSION: Figure 4-23, which was recreated from the Delta Airlines analysis, depicts the streamlines and isotachs at the 250 mb. level for 0000Z on November 27, 1979, which was the approximate time during which most of the RED and BLUE eastbound North Atlantic flights were operating.

The NMC 0000Z analysis for November 26th and the 250 mb. prog. for 0000Z of the 26th, along with an airline operational analysis and the presence of only one minor BLUE Airlines error segment at 53N15W, failed to confirm that the RED Airlines error segments listed above existed. The RED Airlines error segments were apparently based on erroneous data and this date should not have been selected for further review.

The wind barbs plotted on Figure 4-23 are the segment winds from the RED Airlines flight plans on the actual weather. It is obvious that these winds could not have been developed



ORIGINAL PAGE IS
OF POOR QUALITY

Figure 4-23
250 mb. Level
Streamlines & Isotachs
0000Z November 27, 1979

NOTE: Wind Barbs Are
From RED Airlines Flight
Plans.